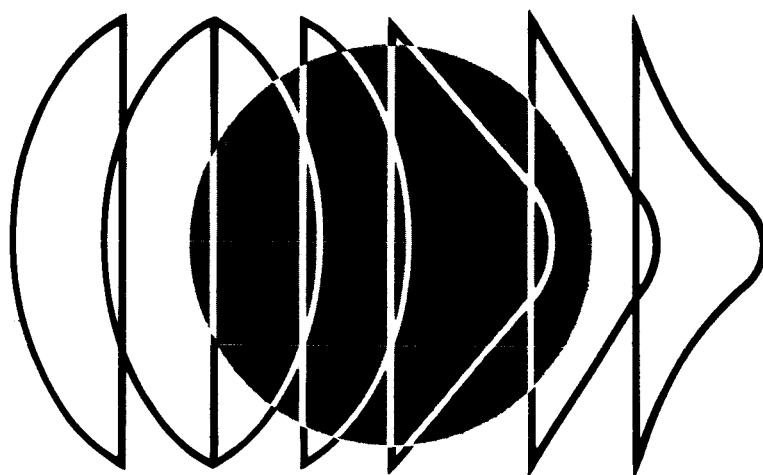


31 AUGUST 1967

PART E RELIABILITY

**VOYAGER
CAPSULE
PHASE B
FINAL REPORT**



VOLUME III SURFACE LABORATORY SYSTEM

PREPARED FOR:
CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
PASADENA, CALIFORNIA
CONTRACT NUMBER 952000

REPORT ORGANIZATION

VOYAGER PHASE B FINAL REPORT

The results of the Phase B Voyager Flight Capsule study are organized into several volumes. These are:

Volume I	Summary
Volume II	Capsule Bus System
Volume III	Surface Laboratory System
Volume IV	Entry Science Package
Volume V	System Interfaces
Volume VI	Implementation

This volume, Volume III, describes the McDonnell Douglas preferred design for the Surface Laboratory System. It is arranged in 5 parts, A through E, and bound in 8 separate documents, as noted below.

Part A	Preferred Design Concept	1 document
Part B	Alternatives, Analyses, Selection	3 documents, Parts B ₁ , B ₂ and B ₃
Part C	Subsystem Functional Descriptions	2 documents, Parts C ₁ and C ₂
Part D	Operational Support Equipment	1 document
Part E	Reliability	1 document

In order to assist the reader in finding specific material relating to the Surface Laboratory System, Figure 1 cross indexes broadly selected subject matter, at the system and subsystem level, through all volumes.

VOLUME III CROSS REFERENCE INDEX

VOLUME III PARTS SYSTEM/SUBSYSTEM		PART A PREFERRED DESIGN CONCEPT Objectives, Constraints - Sys- tem Description, Sequence of Operations, Subsystem Sum- maries.	APPENDIX A (TO PART A) ENVIRONMENTAL REQUIREMENTS	APPENDIX B (TO PART A) FUTURE MISSION CONSIDERATIONS	PART B ALTERNATIVES, ANALYSIS, AND SELECTION Trade Studies, Supporting Analyses, and Results	PART C SLS FUNCTIONAL DESCRIPTIONS Subsystem Descriptions	PART D OPERATIONAL SUPPORT EQUIPMENT Equipment, Software and Trade Studies	PART E RELIABILITY Constraints, Analysis, Results, Testing and Control
Surface Laboratory System								
Mission	Objectives	Section 1	1.1 Environmental Design Criteria	1.1 Exploration Strategies	-	-	1. Introduction & Objectives	-
	Constraints	Section 2	1.1 Environmental Design Criteria	1.1 Exploration Strategies	-	-	2. Requirements & Constraints	1 - Reliability Constraints 4 - Program Requirements
	Profile	Section 3.1	1.5 Mission Environmental Conditions	1.2 Mission Profile	4.7 Extended Mission	-	-	-
	Operations	4.1 Sequence 4.2 Timeline 4.3 Contingency Modes	1.3 Source of Environmental Parameters	-	2 - Mission Analysis	-	8. Software	2 - Failure Mode, Effects, Criticality Analysis 3 - Quantitative Estimates
Design	General	3.2 Configuration	1.2 General 1.4 Environmental Design Requirements	-	1 - Study Approach & Analysis 3 - System Functional Requirements 4 - Major Trade Studies	-	3. Preferred Approach 3.2 Design Concept 6 - ASHE & Servicing Equipment 7 - SC Mounted SLS Equipment 10. Analyses & Trade Studies	5 - Component Part Reliability
	Standardization/Growth	11 - Summary	-	-	-	-	4.3.8, 4.5.8	-
	Weight/Physical Characteristics	5 - Summary & Supporting Data	-	1.6 Constraints	-	-	4.3.3, 4.4.3, 4.5.3	-
Reliability		6 - Philosophy, Implementa- tion, Definitions	-	-	4.6 Resource Allocation	-	4.3.6, 4.4.6, 4.5.6	-
Planetary Quarantine		7 - Contamination Analysis, Design for Sterility	1.6 Sterilization & Decontami- nation	-	-	-	-	-
OSE		8 - General Description	-	-	-	-	Complete OSE Description 3.3 Equipment Summary 4 - System Level Support Equipment 4.3 STC 4.4 LCE 4.5 MDE	-
Interfaces (Also See Volume V)		9 - System Interface Summary	-	-	-	-	4.3.5, 4.4.5, 4.5.5	-
Implementation (Also See Volume VI)		10 - Schedule & Program Summary	-	-	-	-	4.3.7, 4.4.7, 4.5.7	-
Major Subsystems		Section 3.3	-	-	4.3 Analysis of SL Alternatives 5 - Subsystem Studies	Complete Subsystem Func- tional Descriptions	5 - SL Subsystems Level Test Equipment 5.9 Automatic Processor 5.10 Miscellaneous 9. Equipment Summary	-
Electrical Power		3.3.1 - Requirements, Equip- ment Description & Operation	-	1.4 Major Considerations	5.1 Power Studies	Section 1	5.3 EPS Test Set	See Part C - Section 1
Sequencer		3.3.2 - Requirements & Description	-	-	4.4 In-Flight Monitoring & Checkout 5.2 Sequencing & Timing Studies	2.1 Sequencer & Timer 2.2 Test Programmer	5.4 Sequencer Subsystem Test Set	See Part C - Section 2
Control		3.3.3 - Requirements & Description	-	-	5.3 High Gain Antenna Pointing Studies	Section 3	-	See Part C - Section 3
Telecommunications		3.3.4 - Requirements & Description	-	-	5.4 Telecommunications Studies	4. Radio Subsystem 5. Antenna Subsystem 6. Command Subsystem 7. Telemetry Subsystem 8. Data Storage Subsystem	5.5 TCM Test Set	See Part C - Sections 4, 5, 6, 7, and 8
Structure (Including Mechanisms)		3.3.5 - Reqmts & Description 3.3.5.6 - Mechanisms	-	-	4.2 Leveling 5.5 Structural/Mechanical	9. Structure 10. Mechanical	-	See Part C - Sections 9, 10
Pyrotechnic		3.3.6 - Requirements & Description	-	-	Section 5.6	Section 11	5.8 Pyro Initiation Test Set	See Part C - Section 11
Packaging and Cabling		3.3.7 - Description	-	-	Section 5.7	Section 12	-	See Part C - Section 12
Thermal Control		3.3.8 - Description	-	1.5 Major Considerations	Section 5.8	Section 13	5.7 TCS Test Set	See Part C - Section 13
Science		3.3.9 - Sequence & Description 3.3.9.4 - Integration	-	1.3 Major Considerations 2 - Stationary Laboratories 3 - Extended Sample Gathering 4 - Mobile Laboratories 5 - Mobile Systems Performance	4.1 Science Integration 4.5 Independent Data Package Study 5.9.1 Science Data Subsystem 5.9.2 Sample Acquisition & Processing 5.9.3 Science Instruments	14.1 Science Data Subsystem 14.2 Sample Acquisition & Processing Equipment 14.3 Science Instruments	5.6 Science Test Set	See Part C - Section 14

Figure 1

ii - 1

ii - 2

TABLE OF CONTENTS

	<u>Page</u>
PART E RELIABILITY	1
SECTION 1 VOYAGER RELIABILITY CONSTRAINTS	1-1
1.1 No Catastrophic Single Failure Mode	1-1
1.2 Long-Life Storage	1-1
1.3 Unique Environmental Factors	1-1
1.4 Degraded Mode Capability	1-1
SECTION 2 FAILURE MODE EFFECTS & CRITICALITY ANALYSIS (FMECA)	2-1
2.1 FMECA Method	2-1
2.2 FMECA Results	2-1
2.3 Redundancy	2-24
SECTION 3 QUANTITATIVE RELIABILITY ESTIMATES	
3.1 Reliability Estimates Methods	
3.2 Reliability Estimate Limitations	
3.3 Summary of Reliability Estimate Results	
SECTION 4 RELIABILITY PROGRAM REQUIREMENTS	4-1
4.1 Failure Mode, Effects and Criticality Analysis - FMECA	4-1
4.2 Parts and Materials Program	4-1
4.3 Failure Evaluation	4-1
4.4 Design Reviews	4-1
SECTION 5 COMPONENT PART RELIABILITY	5-1
5.1 Approved Parts and Material List	5-1
5.2 Specification	5-2
5.3 Application Manual	5-2
5.4 Testing	5-4
5.5 Control	5-5

This Document Consists of the Following Pages:

Title Page

i through iv

PART E: 1 through 2

1.1

2.1 through 2.32

3.1 through 3.9

4.1

5.1 through 5.6

Appendix A 1 through 30

PART E

RELIABILITY

A summary of Engineering Reliability studies and results are contained herein. Significant attention was given to: 1) satisfying the constraints, 2) failure mode, effect and criticality analyses, 3) quantitative reliability estimates, 4) reliability program requirements and 5) component part reliability.

Reliability has been a key discipline in the VOYAGER system design for the development, integration, and selection processes of our preferred concept. "First time success" and capability for degraded mode operation were the key objectives that guided the reliability analyses. Each design concept was examined in detail to determine its contribution toward achieving these objectives. This was accomplished by utilizing four analytical and modeling techniques:

- a. Failure Mode, Effect, and Criticality Analyses
- b. Reliability-Weight-Effectiveness Analyses
- c. Mission Effectiveness Model
- d. Conceptual tradeoff studies

The most significant of these used by engineering reliability was the single-point failure modes, failure effects, and failure criticality analyses. With this technique, critical or potential single-point failure modes were identified early for the various engineering concepts. These analyses indicated the need for specific redundancies, so that no potential single failure mode could have a catastrophic effect on the mission, and to assure at least a degraded mode of operation.

The selection of the specific type of redundancy (functional, multi-channel, or block) was guided by the failure criticality of the mission event or equipment function. Incorporation of specific redundancies was influenced by the availability of a prime resource -- weight. The reliability-weight-effectiveness analyses resulted in the incorporation of redundancy in the most effective manner to meet the specific mission objectives. Results of these analyses led to the incorporation of seventy-one redundancies thereby resulting in an estimated probability of success of our preferred Surface Laboratory concept of 0.776.

Recognition of equipment sensitivity to long-life storage (in transit) environment was also taken into consideration in our design. Alternate engineering design concepts were evaluated to determine their compatibility with decontamination, sterilization, and Martian environments.

The study revealed that the following reliability program elements must receive

increased major attention throughout the program:

- a. Detail failure mode, effect, and criticality analyses
- b. Specially planned parts and materials program
- c. Positive failure evaluation and corrective action
- d. Comprehensive design reviews

SECTION 1

VOYAGER RELIABILITY CONSTRAINTS

The VOYAGER reliability program constraints were identified by a study of the mission objectives, environmental requirements and predictions, mission profile analysis, total program constraints, and conceptual design studies. The results of this study emphasized the following four constraints which received major reliability attention.

- a. No catastrophic single failure mode
- b. Long-life storage
- c. Unique environmental factors
- d. Degraded mode capability

1.1 NO CATASTROPHIC SINGLE FAILURE MODE - The VOYAGER Capsule Systems Constraints and Requirements Document specifies a design requirement that no potential single-failure mode shall cause a catastrophic effect on the mission. Compliance with this requirement necessitated the identification, evaluation, and resolution of all potential catastrophic failure modes. This was accomplished by using results of our failure mode, effect, and criticality analyses.

1.2 LONG-LIFE STORAGE - Conservative designs, including possible material degradation, influenced our concept selections. Specific details are discussed within the functional descriptions of each subsystem.

1.3 UNIQUE ENVIRONMENTAL FACTORS - The effects of decontamination, sterilization, and the Martian atmosphere and surface properties are unique to the VOYAGER program and were considered in the concept designs to minimize the resultant effect on system reliability.

The system design incorporated the estimated extremes of these characteristics (Reference Volume III, Part A, Appendix A); therefore, for conditions less severe than these extremes, the probability of reliable operation is significantly increased.

1.4 DEGRADED MODE CAPABILITY - A design requirement of system and subsystem concepts was to provide for degraded mode operational capability if primary operational failures occurred. This capability has been provided throughout the design to assure at least some measure of success for unexpected circumstances. For example, partial engineering and science data transmission or retrieval is provided even if the high-rate SL transmitter operates in a degraded mode. In the event of total failure of the high rate transmitter, the low rate transmitter (solid state) provides reduced engineering and science data transmission. Specific design details are discussed within the functional descriptions of each subsystem.

SECTION 2

FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS (FMECA)

Continual engineering reliability analyses were used in identifying and evaluating the failure modes and failure effects of the candidate concepts. Evaluation of the failure mode criticality led to redundancy considerations. These analyses identified the potential single point failure modes. The analyses also provided many design redundancy considerations which are tabulated in Figure 2.0-1.

2.1 FMECA METHOD - The method of performing the FMECA was to first identify the mission objectives;

- a. Achievement of Flight Capsule landing
- b. Performance of Entry Science experiments
- c. Performance of Landed Science experiments
- d. Measurement of transmission of engineering data

After identification of the mission objectives, the candidate concepts were evaluated by

- a. Identifying the major component or function
- b. Identifying their failure modes
- c. Classifying the effects of the failure modes

The depth of the analysis was confined to the detail of the design. In most cases design detail was available down to the component or function level. Figure 2.1-1 is a FMECA performed on the Surface Laboratory Telecommunications subsystem and is representative of the methodology used for all the subsystems. Other major subsystem FMECA's are presented within the subsystem functional descriptions, reference Part C of Volume III. The numbers in the failure category column classify the effects as:

- (1) No effect on the mission objective.
- (2) Degrading effect on mission objective.
- (3) Possible catastrophic effect on mission objective.

Classifications 3-2, 2-1, 3-1, etc., indicate the limits over which the failure effect may vary depending on the degree of failure or the time of occurrence in the mission.

2.2 FMECA RESULTS - Several failure modes, identified by the subsystem FMECA's, had significant effects on the achievement of the mission objectives. These modes are tabulated in the failure mode, effects, and criticality summary, Figure 2.2-1, together with the recommended solutions.

DESIGN CONCEPT REDUNDANCY CONSIDERATIONS

SURFACE LABORATORY FUNCTION	PRIMARY CONCEPT	REDUNDANCY CONSIDERATION	TYPE OF REDUNDANCY
Provide power to SL	Single battery	Provide four batteries, with chargers, sized for worst case mission.	Multichannel
Transfer SL to and from FS power during inter- planetary cruise	MOS command	Provide SL voltage sensor to automatically place SL batteries on line when FS power is absent remove from the line when FS power is present.	Functional
Heating of SL equipment area during interplanetary cruise	Battery heat	Provide resistance heaters	Functional
Encode engineering data for telemetry	Single cruise encoder	Standby redundant cruise encoder	Block
Sample engineering data for telemetry during inter- planetary cruise	Single cruise commutator	Standby redundant cruise commutator. Series redundancy of elements in each sampling channel to prevent loss of commutator function by loss of a single channel.	Block Multichannel
Turn-on SL Test Programmer while in Mars Orbit	CB Test Programmer	Provide MOS command backup	Functional
Perform SL Checkout while in Mars Orbit	SL Test Programmer	Provide MOS command backup Provide standby redundant SL test programmer	Functional Block
Sense Touch-Down on Surface of Mars	SL Impact Sensor	Provide redundant impact sensors	Multichannel
Switch SL to Landed Mode	SL Impact Sensor	Provide redundant impact sensors Provide CB impact sensor backup Provide CB S&T command backup	Multichannel Multichannel Functional
Turn on SL Command Receiver	SL Impact Sensor	Provide CB impact sensor backup Provide SL S&T command backup Provide CB S&T command backup	Multichannel Functional Functional

Figure 2.0-1

DESIGN CONCEPT REDUNDANCY CONSIDERATIONS (Cont.)

SURFACE LABORATORY FUNCTION	PRIMARY CONCEPT	REDUNDANCY CONSIDERATION	TYPE OF REDUNDANCY
Turn on SL Telemetry and Science Data Subsystems	SL impact sensors	Provide CB Impact sensor backup	Multichannel
		Provide SL S&T command backup	Functional
		Provide CB S&T command backup	Functional
		Provide MOS command backup	Functional
Sequencing of SL Mission Events	SL sequencer and timer	Provide redundant SL sequencer and timer	Multichannel
		Provide MOS command backup	Functional
		Provide redundant activation signals, spaced in time, to redundant output drivers	Multichannel
Sense Martian Local Vertical for Antenna Pointing	Pendulous vertical sensor	Provide monopulse Earth track	Functional
		Provide MOS command to per- form matrix search	Functional
Transmission of SL data to Earth	High rate radio link	Provide standby redundant high rate radio link Provide low rate radio link	Block Functional
Receive Earth Commands	Single command receiver	Provide redundant command receiver	Multichannel
		Implement redundant components within command receiver	Multichannel
Radiation of RF Energy to Earth	High gain antenna	Provide redundant medium gain fixed antenna	Functional
		Provide low gain fixed antennas	Functional
High Gain Antenna Pointing	Inertial acquisition and tracking	Provide monopulse Earth track	Functional
		Provide MOS command to per- form matrix search	Functional
		Provide sun sensing backup for antenna pointing	Functional

Figure 2.0 - 1 (Continued)

DESIGN CONCEPT REDUNDANCY CONSIDERATIONS (Cont.)

SURFACE LABORATORY FUNCTION/EVENT	PRIMARY CONCEPT	REDUNDANCY CONSIDERATION	TYPE OF REDUNDANCY
<u>Function</u> Excitation of High Rate Radio Link	Single exciter	Provide standby redundant exciter Provide low rate radio link backup	Block Functional
Heating of SL Equipment and Experiments	Resistance heaters	Provide redundant resistance heaters	Multichannel
Storage of Engineering and Science Data for Delayed Time Telemetry	Tape recorder	Provide standby redundant tape recorder Provide memory core storage backup for tape storage	Block Functional
Panoramic Imaging of Martian Surface	Facimile camera	Provide redundant facimile cameras	Multichannel
Deploy and Release Experiments	Pyrotechnic	Provide dual cartridges	Multichannel
Collect Martian Atmospheric, Biological and Soil Data	Individual experiment for each science data classification	Provide redundant experiments (i.e. four in situ modules) Provide alternate experiments to determine each class of science data	Multichannel Functional
<u>Event</u> Turn on Surface Laboratory Telemetry Subsystem	Surface Laboratory Test Programmer	MOS Command	Functional
Turn on Surface Laboratory Test Programmer	Capsule Bus Test Programmer	MOS Command	Functional
Turn Off Surface Laboratory Telemetry Subsystem	Surface Laboratory Test Programmer	MOS Command	Functional
Turn Off Surface Laboratory Test Programmer	Surface Laboratory Test Programmer	MOS Command	Functional
Switch Surface Laboratory Sequencer and Timer to Landed Mode	Surface Laboratory Impact Sensor	<ul style="list-style-type: none"> • Capsule Bus Impact Sensor • Capsule Bus Sequencer and Timer 	Functional

Figure 2.0-1 (Continued)

DESIGN CONCEPT REDUNDANCY CONSIDERATIONS (Cont.)

SURFACE LABORATORY EVENT	PRIMARY CONCEPT	REDUNDANCY CONSIDERATION	TYPE OF REDUNDANCY
Turn on Surface Laboratory Command Receiver, Telemetry, Science Data Subsystem	Surface Laboratory Impact Sensor	<ul style="list-style-type: none"> • Capsule Bus Impact Sensor • Surface Laboratory Sequencer and Timer • Capsule Bus Sequencer and Timer • Surface Laboratory Test Programmer • Capsule Bus Test Programmer 	Functional
Activate Surface Laboratory Pyrotechnic Charging Capacitor	Surface Laboratory Impact Sensor	<ul style="list-style-type: none"> • Capsule Bus Impact Sensor • Surface Laboratory Sequencer and Timer • Capsule Bus Sequencer and Timer 	Functional
Switch Surface Laboratory Telemetry to Day/Night Mode	Surface Laboratory Sequencer and Timer	<ul style="list-style-type: none"> • Surface Laboratory High Gain Antenna Subsystem • MOS Command 	Functional
Turn On Surface Laboratory Low Rate S-Band Transmitter	Surface Laboratory Sequencer and Timer	Capsule Bus Sequencer and Timer	Functional
Update Surface Laboratory Timer	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Release and Pivot Surface Laboratory Low Gain Antenna Mast	Surface Laboratory Science Data Subsystem	MOS Command	Functional
Turn On High Gain Antenna Control Subsystem	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Unlock High Gain Antenna	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Initiate High Gain Antenna Erection Sequence	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Release Subsurface Probe, Surface Sampler, and Deploy In Situ Experiment Modules	Surface Laboratory Science Data Subsystem	MOS Command	Functional
Start In Situ, Soil Analysis, Atmospheric Properties, Subsurface Probe, Spectroradiometer, Surface Sample Collection and Processing Experiments	Surface Laboratory Science Data Subsystem	MOS Command	Functional

Figure 2.0-1 (Continued)

DESIGN CONCEPT REDUNDANCY CONSIDERATIONS (Cont.)

SURFACE LABORATORY EVENT	PRIMARY CONCEPT	REDUNDANCY CONSIDERATION	TYPE OF REDUNDANCY
Start Low Resolution Visual Imaging, Metabolism, Growth Experiments	Surface Laboratory Science Data Subsystem	MOS Command	Functional
End Low Resolution Visual Imaging	Surface Laboratory Science Data Subsystem	MOS Command	Functional
Turn On High Rate S-Band Transmitter	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Start Medium Resolution Visual Imaging, Surface Sampler Collection, Soil Analysis, Gas Chromatograph Calibration, Subsurface Analysis, Atmospheric Analysis, Soil Volatiles Analysis.	Surface Laboratory Science Data Subsystem	MOS Command	Functional
End In Situ, Soil Analysis, Atmospheric Properties, Subsurface Probe, Spectroradiometer, Surface Sample Collection and Processing, Metabolism Growth, Medium Resolution Visual Imaging, Surface Sampler Collection, Soil Analysis, Gas Chromatograph Calibration, Subsurface Analysis, Atmospheric Analysis, and Soil Volatiles Analysis Experiments	Surface Laboratory Science Data Subsystem	MOS Command	Functional
Turn Off High Rate S-Band Transmitter	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Turn Off Low Rate S-Band Transmitter	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Switch Surface Laboratory Telemetry to Day Mode	Surface Laboratory Sequencer and Timer	MOS Command	Functional
Switch Science Data Subsystem to Terminal Operation Mode	Surface Laboratory Sequencer and Timer	MOS Command	Functional

Figure 2.0-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS
SURFACE LABORATORY - TELECOMMUNICATIONS
ANTENNA SUBSYSTEM

FAILURE CATEGORY DEFINITION								
1 No Effect on Mission Objective								
2 Degrading Effect on Mission Objective								
3 Possible Catastrophic Effect on Mission Objective								
COMPONENT OR FUNCTION		FAILURE MODE	FAILURE EFFECT			REMARKS		
			LANDING	ENTRY SCIENCE	ENG. DATA			
Low Gain Antennas Transmit	RF Breakdown	Loss of low rate engineering and science data	1	1	1	1	High rate radio is primary link - antenna design features consideration of spectrum of atmospheres.	
	Mechanical damage or connections.	Loss of Earth MOS command reception and 2-way doppler tracking	1	1	1	1	Nominal mission objectives are achieved.	
High Gain Antenna Reflector	RF breakdown or mechanical damage	Partial loss of high rate engineering and science data and 2-way doppler tracking	1	1	2	1	Functional redundant low rate radio link available. Antenna design features consideration of spectrum of atmospheres.	
	RF breakdown or mechanical damage	Loss of monopulse tracking capability	1	1	1	1	Inertial acquisition and tracking is primary operating mode	
Mount including drive motors	Mechanical damage, low torque or stall	Partial loss of high rate engineering and science data	1	1	2	1	Functional redundant low rate radio link available.	
	Inoperative or inertial unbalance	Loss of high rate engineering and science data	1	1	2	1	Monopulse tracking mode and Earth commanded antenna search available and low rate radio link. Sun sensor backup mode available for tracking	

Figure 2.1-1

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS
ANTENNA SUBSYSTEM (Cont.)

FAILURE CATEGORY DEFINITION			FAILURE CATEGORY		
1 No Effect on Mission Objective			LANDING SCIENCE		
2 Degrading Effect on Mission Objective			ENTRY SCIENCE		
3 Possible Catastrophic Effect on Mission Objective			ENG. DATA		
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	1	2	REMARKS
Servo Electronics	Inoperative or erroneous error signal output	Loss of high rate engineering and science data	1	1	Monopulse tracking mode and Earth commanded antenna search and tracking available. Low rate radio link available
	Inoperative or pickoff error	Loss of Mars local vertical sensing	1	2	Sensor is passive high reliable function. Monopulse tracking mode and Earth commanded antenna search and tracking available. Low rate radio link available.
Sun Sensor	Aperture or sensor mechanical damage	None; sun sensor provides back-up capability to gyro package	1	1	Inertial acquisition and tracking is primary operating mode
Sun Sensor Pre Amp	Inoperative or erroneous output	None; sun sensor provides back-up capability to gyro package	1	1	Inertial acquisition and tracking is primary operating mode
Diplexer	RF breakdown or mechanical damage	Degradation or loss of RF transmitted or received power	1	2	Functional redundant low rate radio link available. Diplexer is passive, high reliable function.
<u>Power Converter(s)</u>	No power output or low power output	Partial loss of high rate engineering and science data	1	2	Functional redundant low rate radio link available.

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS
RADIO SUBSYSTEM

FAILURE CATEGORY DEFINITION 1 No Effect on Mission Objective 2 Degrading Effect on Mission Objective 3 Possible Catastrophic Effect on Mission Objective				FAILURE CATEGORY		
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	REMARKS	FAILURE CATEGORY		
				LANDING	ENTRY SCIENCE	ENG. DATA
Tracking Receiver	Inoperative or poor sensitivity	Loss of monopulse tracking capability	Inertial acquisition and tracking is primary operating mode.	1	1	1
High Rate Radio Exciter	Inoperative or erroneous frequency output	Loss of high rate engineering and science data and 2-way doppler tracking	Standby redundant exciter being considered and functional redundant low rate radio link available.	1	2	1
Filter/Hybrid	RF breakdown or change in frequency characteristics	Loss of high rate engineering and science data and 2-way doppler tracking	Probability of occurrence is minimal. Functional redundant low rate radio link available and standby redundant high rate radio link being considered.	1	2	1
Attenuators	RF breakdown or overhear	Degraded RF power output - partial loss of high rate data	Standby redundant high rate radio link being considered and functional redundant low rate radio link available.	1	2	1
TWTA	No power output or degraded power output	Total or partial loss of engineering and science data and 2-way doppler tracking	Standby redundant high rate radio TWTA being considered and functional redundant low rate radio link available.	1	2	1

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS

RADIO SUBSYSTEM (Cont.)

FAILURE CATEGORY DEFINITION 1 No Effect on Mission Objective 2 Degrading Effect on Mission Objective 3 Possible Catastrophic Effect on Mission Objective				FAILURE CATEGORY		
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	REMARKS	FAILURE CATEGORY		
				LANDING	ENTRY SCIENCE	ENG. DATA
High Rate Radio (Cont.) Output Filter	RF breakdown or change in frequency characteristics	Total or partial loss of engineering and science data and 2-way doppler tracking	Standby redundant high rate radio link being considered and functional redundant low rate radio link available.	1	1	1
	RF breakdown or RF open Circuit	Total or partial loss of engineering and science data and 2-way doppler tracking	Switch design minimizes probability of failure. Functional redundant low rate radio link available.	1	2	2
Command Receiver	Inoperative or poor sensitivity	Loss of Earth DSN command reception and 2-way doppler tracking	Nominal mission objectives are achieved. Partial backup possible from tracking receiver.	1	1	1
Power Converters	Inoperative or degraded output	Loss of engineering and science data and 2-way doppler tracking if converter is inoperative	Each high rate radio link features individual transmitter power converters if standby transmitter is incorporated.	1	1	2

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.) SURFACE LABORATORY - TELECOMMUNICATIONS

RADIO SUBSYSTEM (Cont.)

FAILURE CATEGORY DEFINITION				FAILURE CATEGORY			
1 No Effect on Mission Objective				LANDING			
2 Degrading Effect on Mission Objective				ENTRY SCIENCE			
3 Possible Catastrophic Effect on Mission Objective				ENG. DATA			
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	REMARKS				
<u>Low Rate Radio</u> <u>Tone Generator</u>	Inoperative or loss of individual frequencies or frequency instability	Loss of low rate radio link if inoperative	High rate radio link is primary operating mode.	1	1	1	
Frequency Converter	Inoperative or frequency instability	Loss of low rate radio link if inoperative	High rate radio link is primary operating mode.	1	1	1	
Transmitter	Inoperative or degraded RF output	Loss of low rate radio link	High rate radio link is primary operating mode.	1	1	1	
<u>Power Converter</u>	Inoperative or degraded output	Loss or degradation of low rate radio link	High rate radio link is primary operating mode.	1	1	1	

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS
COMMAND SUBSYSTEM

FAILURE CATEGORY DEFINITION 1 No Effect on Mission Objective 2 Degrading Effect on Mission Objective 3 Possible Catastrophic Effect on Mission Objective			FAILURE CATEGORY		
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	LANDING		
			ENTRY SCIENCE		
COMMAND DETECTOR	Inoperative or poor sensitivity	Loss of Earth MOS command reception and 2-way doppler tracking.	ENG. DATA		
			REMARKS		
Command Decoder	Inoperative or improper decoding	Loss of Earth MOS command distribution or command error to using subsystems.	1	1	1
			1	1	1
Power Converter	Inoperative or degraded output	Loss of Earth MOS command distribution to using subsystems	1	1	1
			1	1	1

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS

TELEMETRY SUBSYSTEM

FAILURE CATEGORY DEFINITION 1 No Effect on Mission Objective 2 Degrading Effect on Mission Objective 3 Possible Catastrophic Effect on Mission Objective				FAILURE CATEGORY		
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	REMARKS	FAILURE CATEGORY		
				LANDING	ENTRY SCIENCE	ENG. DATA
Instrumentation Equipment	Inoperative data sensor, signal process unit or power converter	Partial or total loss of engineering data dependent on failure	1 1 1 2 Power converter failure would result in the major loss of data. Active redundant (load sharing) converter circuit components are being considered.	1	1	2
Telemetry Equipment Cruise Commutator	Group, subgroup or individual data channel inoperative.	Partial loss of engineering data	1 1 1 2 Data switches are series active redundant.	1	1	2
Cruise Encoder	Inoperative or digital bit errors	Loss of all engineering data if inoperative	1 1 1 2 Standby redundant encoder available, switchable by Earth MOS command.	1	1	2
Engineering Data ADC and Multiplex	Group, subgroup or individual analog data channel inoperative. Encoder (ADC) inoperative or digital bit errors.	Partial loss of engineering data with a multiplex failure. Loss of all engineering data if encoder is inoperative.	1 1 1 2 Series active redundant multiplex data switches are required in output switching decks. Encoder is dormant until landing.	1	1	2
Digital Multiplexer	Group, subgroup or individual digital data channel inoperative	Partial loss of engineering data with a multiplex failure.	1 1 1 2 Series active redundant multiplex data switches are required in output switching decks.	1	1	2

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS

TELEMETRY SUBSYSTEM (Cont.)

FAILURE CATEGORY DEFINITION									
1 No Effect on Mission Objective									
2 Degrading Effect on Mission Objective									
3 Possible Catastrophic Effect on Mission Objective									
COMPONENT OR FUNCTION		FAILURE MODE		FAILURE EFFECT		FAILURE CATEGORY			
						LANDING ENTRY SCIENCE LANDED SCIENCE ENG. DATA			
Data Interleaver and Distributor	Inoperative or improper switching	1	1	2	2	Loss of all engineering and science data if inoperative	1	1	2
							2	2	2
Data Storage Buffer	Inoperative or improper storage delay	1	1	2	2	Loss of all engineering and science data if inoperative	1	1	2
							2	2	2
Convolutional Encoder	Inoperative or erroneous encoder output	1	1	2	2	Loss of all engineering and science data if inoperative	1	1	2
							2	2	2
Subcarrier Modulator	Inoperative or frequency instability	1	1	2	2	Loss of all engineering and science data if inoperative	1	1	2
							2	2	2
REMARKS									
Series active redundant data interleaver switches are required to minimize failure effect.									
Control electronics should be redundacized to assure buffer readout. Telemetry link design will accomodate variation in storage delay.									
Functional redundant low rate radio link available. Encoder has relatively short mission duty cycle.									
Modulator has relatively short mission duty cycle. Functional redundant low rate radio link available.									

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS
TELEMETRY SUBSYSTEM (Cont.)

FAILURE CATEGORY DEFINITION 1 No Effect on Mission Objective 2 Degrading Effect on Mission Objective 3 Possible Catastrophic Effect on Mission Objective				FAILURE CATEGORY			
				Landing Entry Science Landed Science Eng. Data			
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	REMARKS				
Programmer and Experiment Controller	Inoperative or partial loss of sequencing and control	Loss of all engineering and science data if inoperative	1	1	2	2	Design features decentralization of sequencing and controlling functions for minimum failure effect.
	Inoperative, unstable clock frequency or partial loss of clock rates	Loss of all engineering and science data if inoperative	1	1	1	1	Clock generator crystals are redundant and temperature compensated. The clock is free running and externally synchronized by the S.L.S. sequencer and timer primary frequency clocks.
Power Converter(s)	Inoperative or degraded output	Loss of all engineering and science data if inoperative	1	1	2	2	Active redundant (load sharing) circuit components are being considered.

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
SURFACE LABORATORY - TELECOMMUNICATIONS
DATA STORAGE SUBSYSTEM

FAILURE CATEGORY DEFINITION 1 No Effect on Mission Objective 2 Degrading Effect on Mission Objective 3 Possible Catastrophic Effect on Mission Objective		FAILURE CATEGORY				REMARKS
		LANDING	ENTRY SCIENCE	LANDED SCIENCE	ENG. DATA	
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT				
<u>Tape Recorder</u>	Inoperative in record or playback modes of operation	1	1	2	2	Realtime engineering and science data are obtained. Functionally redundant data storage units with switchable input data electronics are being considered to minimize effect of a major electromechanical failure.

Figure 2.1-1 (Continued)

SCIENCE DATA SUBSYSTEM

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS (Cont.)
 SURFACE LABORATORY - TELECOMMUNICATIONS

SCIENCE DATA SUBSYSTEM (Cont.)

FAILURE CATEGORY DEFINITION				FAILURE CATEGORY			
1 No Effect on Mission Objective				LANDING			
2 Degrading Effect on Mission Objective				ENTRY SCIENCE			
3 Possible Catastrophic Effect on Mission Objective				LANDED SCIENCE			
				ENG. DATA			
COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT					REMARKS
Power Converter(s)	Inoperative or degraded output	Partial loss of science data	1	1	2	1	Power converters for remote interface units are decentralized for minimum loss of science data in event of individual failures (multichannel cooperative redundancy feature)

Figure 2.1-1 (Continued)

FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS SUMMARY

COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	CRITICAL MISSION PHASE	RECOMMENDATION
<u>Electrical Power</u>				
Main Batteries (four)	Degraded or no output	Degraded mission (dependent on mission energy requirements)	Landed mission	Provide four surface laboratory batteries sized for worst case mission. Provide backup capability by using capsule bus power during landed mission.
Battery Chargers (four)	Failure to charge batteries during interplanetary cruise	Degraded mission (dependent on mission energy requirements)	Interplanetary cruise	Provide four surface laboratory batteries sized for worst case mission. Provide backup capability by using capsule bus power during landed mission.
<u>Resistance Heaters and Thermostats</u>				
Resistance Heaters	Failure to provide adequate thermal output	Degradation of temperature effected equipments and experiments	Landed mission	Provide redundant resistance heaters
Thermostats	Failure to provide adequate thermal control	Degradation of temperature effected equipments and experiments	Landed mission	Provide redundant thermostats
<u>Heat Pipe</u>				
Radiators and Pipes	Failure to dissipate equipment generated heat(Martian Day)	Degradation of temperature effected equipments and experiments	Landed mission	Provide redundant heat pipes
Control Valves	Dissipation of heater thermal output (Martian Night)	Degraded mission due to excess night power for heaters	Landed mission	Provide redundant control valves
<u>Sequencer & Timer</u>	No output			
DC-DC Converter	No output	All timed events fail to occur	Landed phase	Provide redundant DC-DC converter. Provide MOS command backup.
Master Oscillator	No output	All timed events fail to occur	Landed phase	Provide active redundant oscillators. Provide MOS command backup.

Figure 2.2-1

FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS SUMMARY (Continued)

COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	CRITICAL MISSION PHASE	RECOMMENDATION
Memory Buffer Register	Failure to allow data transfer to or from memory	Loss of all timing functions other than frequency generator	Landed phase	Provide duplexed memories and registers Provide MOS command backup
Decrementers and zero detectors	Failure to decrement memory time word	All timed events fail to occur	Landed phase	Provide triple redundant zero detectors with majority voter Provide MOS command backup
	Failure to detect zero	All timed events fail to occur	Landed phase	Provide triple redundant zero detectors with majority voter Provide MOS command backup
Frequency Dividers	Fails to divide	All timed events fail to occur	Landed mission	Provide triple redundant frequency dividers with majority voter Provide MOS command backup
Telecommunications				
Cruise Commutator	Group, subgroup or individual data channel inoperative (shorted)	Loss of engineering data	Interplanetary cruise	Provide series redundant data switches to prevent loss of commutator function by loss of a single channel
Cruise Encoder	Inoperative or digital bit errors	Loss of all engineering data if inoperative	Interplanetary cruise	Provide standby redundant encoder to be switched by Earth command
Clock Generator	Inoperative or Unstable	Loss of all engineering & science data if inoperative	Landed mission	Provide redundant temperature compensator crystal controlled clocks Provide free running capability for external synchronization from SL Sequencer and Timer

Figure 2.2-1 (Continued)

FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS SUMMARY (Continued)

COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	CRITICAL MISSION PHASE	RECOMMENDATION
Power Converter	Inoperative or degraded output	Loss of all engineering & science data if inoperative	Landed mission	Provide active redundant load sharing circuit components
Programmer and Experiment Controller	Inoperative or partial loss of sequencing and control	Loss of all engineering & science data if inoperative	Landed mission	Provide decentralization of sequencing and control functions for minimum failure effect
High Gain Antenna	RF breakdown	Loss of high rate radio link	Landed mission	Provide low gain antenna for use by low rate radio link
	Mechanical damage (impairing RF radiation)	Partial loss of high rate engineering and science data	Landed mission	Provide low gain antenna for use by low rate radio link
	Failure of inertia pointing	Loss of high rate radio link	Landed mission	Provide monopulse Earth tracking mode Provide MOS command to perform matrix search Provide sun sensor for antenna pointing Provide low rate radio link Provide redundant gyros and gimbal drive motors
High rate transmitter	No power output or degraded output	Total or partial loss of engineering and science data	Landed mission	Provide standby redundant TWTAs Provide standby redundant exciter Provide low rate radio link
Command receiver	Inoperative or degraded output	Loss of MOS command capability	Landed mission	Provide active redundant circuit components in Command Receiver Utilize tracking receiver for limited backup capability

Figure 2.2-1 (Continued)

FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS SUMMARY (Continued)

COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	CRITICAL MISSION PHASE	RECOMMENDATION
Tape Recoder	Inoperative in record or playback modes of operation	Loss of all delayed engineering and science data	Landed mission	Provide core memory storage back-up for tape recoder Provide functional redundant tape recorder
Pyrotechnics				
In-Situ Experiment mortars	Failure to deploy in-situ specific life detectors	Failure to obtain in-situ life data	Landed mission	Provide redundant cartridges in pyro devices
Explosive Releases	Failure to release high gain antenna for tracking, atmospheric data probe, surface and sub-surface probes	Loss of high gain radio link, partial loss of atmospheric and surface data, loss of sub-surface data	Landed mission	Provide redundant cartridges in pyro devices
Experiments				
Facsimile Camera	Failure to provide panoramic imaging of Martian surface	Failure to obtain video data	Landed mission	Provide redundant facsimile cameras
In-Situ Specific Life Detectors	Failure to deploy in-situ life detector packages	Failure to obtain specific life data at locations remote from landing location	Landed mission	Provide four independent in-situ specific life detector packages and associated mortars
Atmospheric Pressure Transducer	Fails to detect pressure	Failure to obtain Martian surface pressure	Landed mission	Provide redundant atmospheric pressure transducer Utilize ESP pressure transducer data
Atmospheric Temperature Transducer	Fails to measure temperature	Failure to obtain Martian surface temperature	Landed mission	Provide redundant temperature transducers Utilize ESP temperature transducer data
Atmospheric Humidity Sensor	Fails to measure atmospheric moisture content	Failure to obtain Martian surface humidity data	Landed mission	Provide redundant humidity sensor

Figure 2.2-1 (Continued)

FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS SUMMARY (Continued)

COMPONENT OR FUNCTION	FAILURE MODE	FAILURE EFFECT	CRITICAL MISSION PHASE	RECOMMENDATION
Anemometers	Fails to detect wind velocity and direction	Failure to obtain Martian surface "wind" data	Landed mission	Provide "high speed" and "low speed" anemometers Provide three directional "hot wire" anemometers Provide one OMNI "hot wire" anemometer Provide standby redundant directional and OMNI anemometers
Spectro-Radiometer	Fails to function	Failure to obtain Martian isolation and surface spectral characteristics and surface thermal radiation measurements	Landed mission	Provide "narrow angle" and "wide angle" spectro-radiometers
Alpha Spectrometer	Fails to function	Failure to obtain Martian soil element analysis	Landed mission	Provide internal standby redundancy
Gas Chromatograph	Fails to function	Failure to obtain atmospheric and subsurface gas analysis and subsurface soil analysis	Landed mission	Provide standby redundant double length column for soil analysis. Perform computer optimization to permit change in flow rate or temperature to compensate for failure to obtain desired temperature or flow rate.
Sub-surface Probe	Fails to function	Failure to obtain sub-surface temperature and gas samples	Landed mission	Provide multiple thermocouples to detect sub-surface temperatures.
Surface sample acquisition Equipment	Fails to function	Failure to obtain alpha spectrometer data, gas chromatograph soil analysis and failure to obtain growth and life detector measurements except by in-situ life detectors	Landed mission	Provide "drag line" surface sampler to complement surface sampler "boom".

Figure 2.2-1 (Continued)

2.3 REDUNDANCY - Redundancy was necessary to meet the criterion that no potential single failure mode shall cause a catastrophic effect on the mission and also to assure a high level of success in achieving the mission objectives. An initial prime requirement for the Flight Capsule design was to find an optimum breakdown, arrangement, or interlacing of subsystems. By such means, it was desired to have a number of subsystems provide backup to other subsystems to achieve functional redundancy. Such benefit, although in degraded mode, is accomplished without the expense of added weight. This approach is not based on equipment duplication but rather upon being able to accomplish the function in an alternate manner. As a result, functional redundancy is our preferred approach, wherever practical. Three types of redundancies were considered and criteria for effective allocation of these redundancies was developed.

2.3.1 Types of Redundancies - Three redundancy schemes were studied and utilized in the system design. Each type of redundancy has its particular advantages. The decision to use one or another required careful consideration of the particular application and its possible consequences.

- a. Alternate Path or Functional Redundancy Method - This redundancy is characterized by providing two or more physically different but functionally identical methods to accomplish a function. The prime objective in employing this method is to provide at least two separate and independent paths by which critical operations may be performed. This type is the preferred choice because it offers greater protection against generic failure modes and unknown environmental stresses. It can be designed into the system at relatively low penalty in terms of weight, volume, power, and system complexity.
- b. Cooperative Multi-channel Methods - This redundancy is characterized by dividing the equipment for performing the function into two or more independent portions in such a manner that some portion can fail and the function can still be performed with minimum or no degradation. This type is the next choice because no failure detection or switching features are required with this method. It is normally designed into the system at a moderate penalty in weight, volume, and power.
- c. Ordinary Block or Element Redundancy Method - This redundancy is characterized by the paralleling of two identical units in which failure of the operating unit is sensed and identical equipment is switched in to accomplish the function. This type is the least desirable because both units are susceptible to the same failure modes if exposed to overstressed

conditions. It also requires the addition of a detection and switching unit therefore providing the least overall reliability improvement. In addition, parallel units with a detection and switching unit more than doubles the weight and increases power requirements.

2.3.2 Reliability Versus Weight - The FMECA led to many suggested possibilities for the incorporation of redundancies. However, the addition of redundancies represents a corresponding weight increase. Thus, an initial criterion for decision on redundancy incorporation needed to be established. This criterion was a requirement for achieving maximum increase in reliability with a minimum weight increase. An illustration of the implementation of this criterion is shown in Figure 2.3.2-1. The failure rate (λ) for each component, system or subsystem must be utilized in establishing the non-redundant reliability (R_o) from the equation:

$$R_o = e^{-\lambda t} ; (\ln R_o = -\lambda t)$$

Then the reliability improvement for each subsequent change ($\Delta \ln R$) was calculated by:

$$R_i = e^{\ln R_o + \Delta \ln R}; \quad \Delta \ln R = \ln R_i - \ln R_o$$

Preference was given the component with the lowest weight increase for an incremental change in reliability ($\Delta W/\Delta \ln R$) followed by units of increasing $\Delta W/\Delta \ln R$. Utilization of this criterion resulted in the redundancy considerations shown in Figure 2.3.2-2 and indicated the potential reliability improvement as shown in Figure 2.3.2-3. This technique of redundancy considerations as applied to the Surface Laboratory, placed equal emphasis on the achievement of each mission objective. The competing characteristics of the Performance and Design Requirements for the 1973 mission indicates that equal emphasis should not be placed on each mission objective. Therefore, an additional analytical technique was needed based on the priority of these objectives. Fulfillment of this need was accomplished by an effectiveness analysis study for the redundancy considerations.

2.3.3 Effectiveness Analysis - The effectiveness analysis study is the adaptation of a technique which evaluated the redundancy in terms of the achievement of the mission objective. The equation developed was:

$$E = V_1 R_1 + V_2 R_2 + V_3 R_3$$

SEQUENCER & TIMER (S & T)

RELIABILITY VS. WEIGHT

COMPONENT	BASELINE				ALTERNATE					
	(1) t _m	(2) λ	(3) -1nRX10 ⁶	W (lbs)	(4) -1nRX10 ⁶	W (lbs)	Δ1nRX10 ⁶	ΔW (lbs)	ΔW/ Δ1nR	Change
Surface Laboratory S & T										
Address Register	168	.4	67.2	.02	33.6	.0712	33.6	.0512	1523	C14-S
Command Link Interface	168	.2	33.6	.01	33.6	.042	0	.032		C34-S
Control	168	2.9	487.2	.28	134.4	.888	352.8	.608	1723	C18-S
Crystal Clock	168	.8	134.4	.26	18.8	.588	115.6	.328	2837	C24-S
Digital Data Interface	168	1.0	168.0	.06	33.6	.192	134.4	.132	982	C2-S
Earth/Sun Cyclic Register	168	1.6	268.8	.09	67.2	.294	201.6	.204	1012	C4-S
Instruction Counter	168	.4	67.2	.02	33.6	.0712	33.6	.0512	1523	C13-S
Memory	168	12.5	2100.0	4.00	205.6	8.094	1894.4	4.094	2161	C21-S
Memory Buffer Register	168	1.4	235.2	.08	33.6	.252	201.6	.172	853	C1-S
Output Decoder & Interface	168	8.1	1360.8	.94	592.0	2.22	768.8	1.28	1664	C17-S
Power Detector	168	.2	33.6	.04	16.8	.086	16.8	.046	2738	C23-S
Power Supply	168	5.3	890.4	2.21	100.8	4.468	789.6	2.258	2859	C25-S
Reference Frequency Interface	168	.3	50.4	.07	16.8	.216	33.6	.146	4345	C31-S
Sensor Interface	168	.7	117.6	.04	33.6	.132	84.0	.092	1095	C6-S
Shutdown Generator	168	.2	33.6	.05	16.8	.108	16.8	.058	3452	C27-S
Telemetry Interface	168	1.0	168.0	.06	33.6	.192	134.4	.132	982	C3-S
Timing Generator	168	1.5	252.0	.08	100.8	.276	151.2	.196	1296	C8-S
Zero Detector & Decrementer	168	.6	100.8	.03	33.6	.102	67.2	.072	1071	C5-S

1-92-2

- (1) Modified time factor x time (hours)
- (2) λ = Failure per Million Hours
- (3) $- 1nRX10^6 = t_m \lambda$
- (4) Computed $1nR$ and weight based on added redundancy

Figure 2.3.2-1

Configuration	ΔW (lbs)	$\Sigma \Delta W$ (lbs)	$\Delta 1nRX10^6$	$\Sigma 1nRX10^6$
Baseline	-	-		.006569
C1S	.17	.17	.000202	.006367
C2S	.13	.30	.000134	.006233
C3S	.13	.44	.000134	.006099
C4S	.20	.64	.000202	.005897
C5S	.07	.71	.000067	.005830
C6S	.09	.80	.000084	.005746
C31S	.15	23.24	.000034	.001539

- C1S - Incorporate Triple Redundant Memory Buffer Registers with Majority Voter.
 C2S - Incorporate Triple Redundant Digital Data Interfaces with Majority Voter.
 C3S - Incorporate Triple Redundant Telemetry Interfaces with Majority Voter.
 C4S - Incorporate Triple Redundant Earth/Sun Cyclic Registers with Majority Voters.
 C5S - Incorporate Triple Redundant Zero Detectors & Decrementers with Majority Voter.
 C6S - Incorporate Triple Redundant Sensor Interfaces with Majority Voter.
- C31S - Incorporate Triple Redundant Reference Frequency Interfaces with Majority Voter.

SURFACE LABORATORY REDUNDANCY CONSIDERATIONS

RELIABILITY VERSUS WEIGHT

ORDER OF PRIORITY	REDUNDANCY CONSIDERATION	SUBSYSTEM	TYPE
1	Standby redundant cruise encoder	Telecommunications	Block
2	Series active redundant cruise commutator, data switches and switch drivers	Telecommunications	Multichannel
3	Active redundant battery charger relay #1	Electrical Power	Multichannel
4	Active redundant battery charger relay #2	Electrical Power	Multichannel
5	Active redundant battery charger relay #3	Electrical Power	Multichannel
6	Active redundant battery charger relay #4	Electrical Power	Multichannel
7	Standby redundant TV data process electronics	Telecommunications	Block
8	Standby redundant commutator and encoder	Telecommunications	Block
9	Standby redundant convolution coder	Telecommunications	Block
10	Dual channel active redundant command subsystem (decoder)	Telecommunications	Multichannel
11	Redundant tape recorder storage	Telecommunications	Functional
12	Standby redundant programmer	Telecommunications	Block
13	Redundant low rate radio link (partial mission success)	Telecommunications	Functional
14	Redundant high gain antenna pointing and steering (monopulse tracking)	Telecommunications	Functional
15	Active redundant crystal controlled oscillators	Sequencer & Timer	Multichannel
16	Duplex memories and memory buffer registers with error detection switching logic	Sequencer & Timer	Block
17	Triple redundant frequency dividers with majority voters at each use point	Sequencer & Timer	Multichannel
18	Dual cartridge pyrotechnic devices - surface laboratory experiment deploy and release	Staging	Multichannel
19	Triple redundant decrementers and zero detectors with majority voters	Sequencer & Timer	Multichannel

Figure 2.3.2-2

2-27 - 1

2-27-2

20	Standby redundant science data remote interface units and controller	Telecommunications	Block
21	Standby redundant core storage buffer	Telecommunications	Block
22	Active redundant discrete output line drivers	Sequencer & Timer	Multichannel
23	Active redundant antenna sequencing logic	Telecommunications	Multichannel
24	Standby redundant servo electronics	Telecommunications	Block
25	Active redundant (load sharing) telemetry power supply	Telecommunications	Multichannel
26	Triple redundant control logic with majority voters	Sequencer & Timer	Multichannel
27	Active redundant sensor interfaces	Sequencer & Timer	Multichannel
28	Active redundant telemetry, command link, reference frequency and digital data interfaces	Sequencer & Timer	Multichannel
29	Triple redundant discrete output gates with majority voters	Sequencer & Timer	Multichannel
30	Dual channel active redundant command receiver - power supply assembly	Telecommunications	Multichannel
31	Active redundant (load sharing) servo electronics power supply	Telecommunications	Multichannel
32	Active redundant bias voltage and logic voltage regulators	Sequencer & Timer	Multichannel
33	Quad redundant input power diodes	Electrical Power	Multichannel
34	Active redundant (load sharing) pedestal drive	Telecommunications	Multichannel

27

				Block
35	Standby redundant high rate radio transmitter		Telecommunications	Multichannel
36	Active redundant subsystem control relays (20)		Electrical Power	Multichannel
37	Active redundant subsystem load sensors (18)		Electrical Power	Multichannel
38	Active redundant battery #1 relay		Electrical Power	Multichannel
39	Active redundant battery #2 relay		Electrical Power	Multichannel
40	Active redundant battery #3 relay		Electrical Power	Multichannel
41	Active redundant battery #4 relay		Electrical Power	Multichannel
42	Active redundant high power transmitter relay		Electrical Power	Multichannel
43	Active redundant heater bus relay		Electrical Power	Multichannel
44	Active redundant experiment thermoelectrics		Thermal Control	Multichannel
45	Active redundant experiment thermostats		Thermal Control	Multichannel
46	Active redundant proximity thermostats		Thermal Control	Multichannel
47	Quad redundant battery #1 diodes		Electrical Power	Multichannel
48	Quad redundant battery #2 diodes		Electrical Power	Multichannel
49	Quad redundant battery #3 diodes		Electrical Power	Multichannel
50	Quad redundant battery #4 diodes		Electrical Power	Multichannel
51	Active redundant proximity resistance heaters		Thermal Control	Multichannel
52	Active redundant experiment resistance heaters		Thermal Control	Multichannel

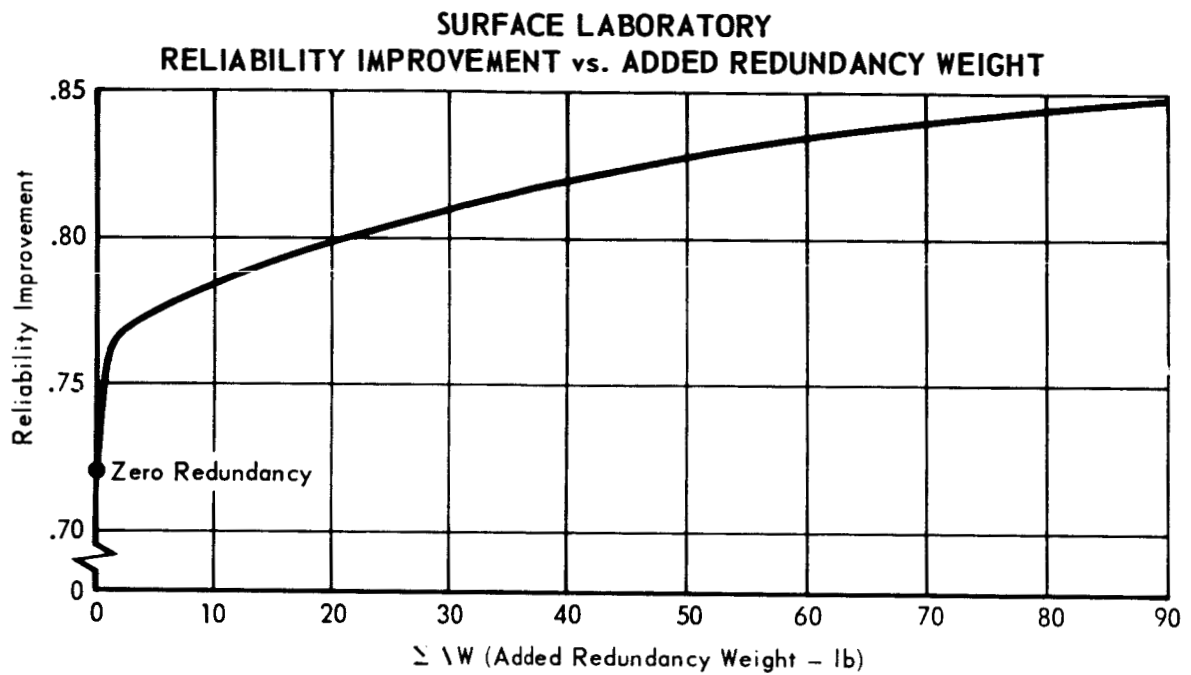


Figure 2.3.2-3

where V_1 = Value index for the achievement of landing

V_2 = Value index for the performance of Entry Science experiments

V_3 = Value index for the performance of Landed Science experiments

and, R_1 = Reliability index for the achieved landing

R_2 = Reliability index for the performance of Entry Science experiments

R_3 = Reliability index for the performance of Landed Science experiments

Based on the competing characteristics criterion described in the "Specification for Performance and Design Requirements for the 1973 VOYAGER Mission", it was established that the value index should have the relationship $V_1 + V_2 + V_3 = 1$ and $V_1 > V_2 > V_3$. An effectiveness model was developed and is described and shown in Part B Section 4.6 of Volume III.

As an example of the results of this analysis, Figure 2.3.3-1 shows a tabulation of the priority rating for redundancy considerations based on the assignment of value indices: $V_1 = .40$, $V_2 = .35$ and $V_3 = .25$. Comparisons of redundancy considerations from a reliability versus weight analysis and an effectiveness analysis are tabulated in the same Figure.

2.3.4 Summary of Selected Redundancies - Engineering judgment and the effectiveness analysis results were used as the criteria for selecting the preferred system concept redundancies. The primary criterion, engineering judgment, required back-up capability for the performance of all critical mission events. This capability was provided regardless of the efficiency of weight increase to reliability improvement. After providing this capability, the selection of additional equipment redundancies was guided by the effectiveness analysis. The seventy-one (71) redundancies selected for the preferred concept are tabulated in Figure 2.3.4-1. Fifty-nine (59) are functional and consequently added minimal weight.

2.3.5 Redundancy Implementation Policy - The basic redundancy implementation policy was modified as a result of the effectiveness analysis. Prior to this analysis, equal emphasis was placed on the redundancy considerations for Capsule Bus, Entry Package and Surface Laboratory. As the design concepts evolved, it became apparent this policy of equal emphasis must be modified to most effectively utilize a prime resource--weight. Therefore the effectiveness analysis technique was used as the redundancy implementation policy.

RELIABILITY VERSUS WEIGHT AND EFFECTIVENESS ANALYSIS

REDUNDANCY PRIORITY COMPARISON

REL. vs. WT.	EFF. ANAL.	REDUNDANCY CONSIDERATION	SUBSYSTEM	TYPE
1	1	Standby redundant cruise encoder	Telecommunications	Block
2	2	Series active redundant cruise commutator, data switches and switch drivers	Telecommunications	Multichannel
3	3	Active redundant battery charger relay #1	Electrical Power	Multichannel
4	4	Active redundant battery charger relay #2	Electrical Power	Multichannel
5	5	Active redundant battery charger relay #3	Electrical Power	Multichannel
6	6	Active redundant battery charger relay #4	Electrical Power	Multichannel
7	7	Standby redundant TV data process electronics	Telecommunications	Block
8	8	Standby redundant commutator and encoder	Telecommunications	Block
9	9	Standby redundant convolution coder	Telecommunications	Block
10	10	Dual channel active redundant command sub-system (decoder)	Telecommunications	Multichannel
11	11	Redundant tape recorder storage	Telecommunications	Functional
12	12	Standby redundant programmer	Telecommunications	Block
13	13	Redundant low rate radio link (partial mission success)	Telecommunications	Functional
14	14	Redundant high gain antenna pointing and steering (monopulse tracking)	Telecommunications	Functional
15	15	Active redundant crystal controlled oscillators	Sequencer & Timer	Multichannel
16	16	Duplex memories and memory buffer registers with error detection switching logic	Sequencer & Timer	Block
17	17	Triple redundant frequency dividers with majority voters at each use point	Sequencer & Timer	Multichannel
18	18	Dual cartridge pyrotechnic devices - surface laboratory experiment deploy and release	Staging	Multichannel
19	19	Triple redundant decrementers and zero detectors with majority voters	Sequencer & Timer	Multichannel
20	20	Standby redundant science data remote interface units and controller	Telecommunications	Block

Figure 2.3.3-1

2-30-1

[illegible]

2-31 -/

	<p>Indication (3 Times)</p> <ul style="list-style-type: none"> ● Unlock High-Gain Antenna ● Initiate High-Gain Antenna Erection Sequence ● Release Subsurface Probe ● Release Surface Sampler ● Deploy In Situ Life Experiment Modules (4) ● Start In Situ Portion of Metabolism Experiment ● Start Soil Analysis Experiment in Background Count Mode ● Start Atmospheric Properties in Day/Night Mode ● Start Subsurface Probe Experiment in Day/Night Mode ● Start Spectroradiometer Experiment ● Start Surface Sample Collection (3 Times) ● Start Low Resolution Visual Imaging ● Start Metabolism Experiment ● Start Growth Experiment ● End Low-Resolution Visual Imaging ● Turn on SL High Rate S-Band Transmitter 	<ul style="list-style-type: none"> ● SL Sequencer and Timer ● SL Sequencer and Timer ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● System Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System ● Science Data System 	<ul style="list-style-type: none"> ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System ● Mission Operations System
--	---	---	--

SURFACE LABORATORY SELECTED REDUNDANCIES (Continued)

TYPE	SUBSYSTEM EQUIPMENT REDUNDANCIES	SUBSYSTEM
Multichannel Block	SL Batteries Provide Backup Power for CB & ESP Without Additional Battery Weight	Electrical Power
Multichannel	Standby Redundant Cruise Encoder	Telecommunications
Multichannel	Series Active Redundant Cruise Commutator Data Switches and Switch Drivers	Telecommunications Instrumentation
Functional	Active Redundant Impact Sensors	Telecommunications
Functional	Monopulse Earth Track and Commanded Antenna Matrix Search Backup to the Inertial Antenna Pointing and Tracking Mechanism.	Telecommunications
Functional	Active Redundant Low Rate Radio Link Backup to the High Rate Radio Link.	Thermal Control
Multichannel	Resistance Heaters are Redundant to Battery Heat During Cruise Phase	Sequencing and Timing
Multichannel	Redundant Sequencer and Timer Discrete Activation Signals, Spaced in Time to Redundant Output Drivers	Experiment
Multichannel	Redundant Facsimile Cameras	Pyrotechnic
Multichannel	Dual Cartridge Mortars for in SITU Life Detectors	Pyrotechnic
Multichannel	Active Redundant Pyrotechnic Firing Capacitors and Circuitry	Pyrotechnic
Multichannel	Dual Cartridge Pyrotechnic "Pin-Pullers" for Equipment Release	Telecommunications
Functional	Limited Tracking Receiver	
Multichannel	Backup of Command Receiver	Experiment
Block	Active Redundant in SITU Life Detector Packages (4)	Experiment
Functional	Standby Redundant Directional and Omni Anemometers	Experiment
Multichannel	"Wide Angle" Remote Unit Spectroradiometer Backed up by "Narrow Angle" Unit	Experiment
	Active Redundant Thermocouples for Detection of Subsurface Temperatures	Experiment

Figure 2.3.4-1 (Continued)

SECTION 3

QUANTITATIVE RELIABILITY ESTIMATES

The primary purpose of the reliability estimates is to show relative comparisons of reliability potentials of the many concepts considered, rather than to accurately predict the reliability of a given concept or the preferred concept.

3.1 RELIABILITY ESTIMATE METHODS - The methods used in performing reliability estimates for the studies were maintained consistent with the level of design maturity. The primary elements necessary for establishing a quantitative reliability estimate are discussed in the following paragraphs.

3.1.1 Mission Profile Analysis - The mission profile presented in the VOYAGER Specification was examined in detail and a representative mission for the Surface Laboratory was established for reliability estimates. Mission events were examined to determine the possible effect of the events on subsystem reliability. This examination resulted in the establishment of failure rate modifiers to be applied in determining an equivalent mission duty cycle. The mission events and applicable failure rate modifying factors are listed in Figure 3.1.1-1. Modifying factors are shown for both operating and non-operating equipment. The factors depict the significant relative environmental and application stresses for the different events.

3.1.2 Subsystem Configuration Definition - A necessary step in the computation of a reliability estimate is to determine the function and operations of the subsystem and its major components or assemblies. This was accomplished by a study of the subsystem functional block diagram. A typical subsystem functional block diagram is illustrated by Figure 3.1.2-1.

From this information a reliability logic diagram was prepared for the subsystem. This is a "success path" diagram showing those components and/or sub-assemblies which must function in order for the subsystem to successfully complete its mission. The reliability diagram expands in detail as the design matures. A typical reliability block diagram is illustrated by Figure 3.1.2-2.

3.1.3 Failure Rate Determination - With a subsystem reliability diagram defined, the next step in performing a reliability estimate was to determine a failure rate for each item or block in the reliability diagram. For the less complex sub-assemblies and/or components which appear in the diagram, the historical failure rate of a similar item was used. The parts count technique, as illustrated by

**VOYAGER MARS MISSION PROFILE AND FAILURE RATE MODIFYING FACTORS
FOR RELIABILITY ANALYSIS**

MISSION EVENT	TIME (HRS)	MODIFYING FACTOR		MODIFIED TIME - t_m	
		OPERATING EQUIPMENT	NON-OPERATING EQUIPMENT	OPERATING EQUIPMENT	NON-OPERATING EQUIPMENT
Launch	0.20	150	150	30	30
Parking Orbit	0.54	1	.01	.54	.0054
Interplanetary Injection (Powered Flight)	0.09	3	3	.27	.27
Interplanetary Cruise (222 days + 4 days)	5424	1	0.01	5424	54.24
Trajectory Corrections (Powered Flight)	0.10*	3	3	.30	.30
Orbit Insertion (Powered Flight)	0.10*	3	3	.30	.30
Orbit Cruise (7.5 Orbits)	105	1	.01	105	1.05
De-orbit Maneuver (Powered Flight)	0.02	3	3	.06	.06
Orbit Descent	5	1	.01	5	.05
Entry	.10	6	6	.60	.60
Terminal Descent Aero	0.02	3	3	.06	.06
Terminal Descent Prop	0.02	6	6	.12	.12
Impact	.01	3,000	3,000	30	30
Landing Erection	.02	3	3	.06	.06
Landing Operation					
Exterior	≤ 50	5	.01	≤ 250	.50
Interior	≤ 50	1	.01	≤ 50	.50

* Estimate

Figure 3.1.1-1

SL SEQUENCER AND TIMER SCHEMATIC BLOCK DIAGRAM

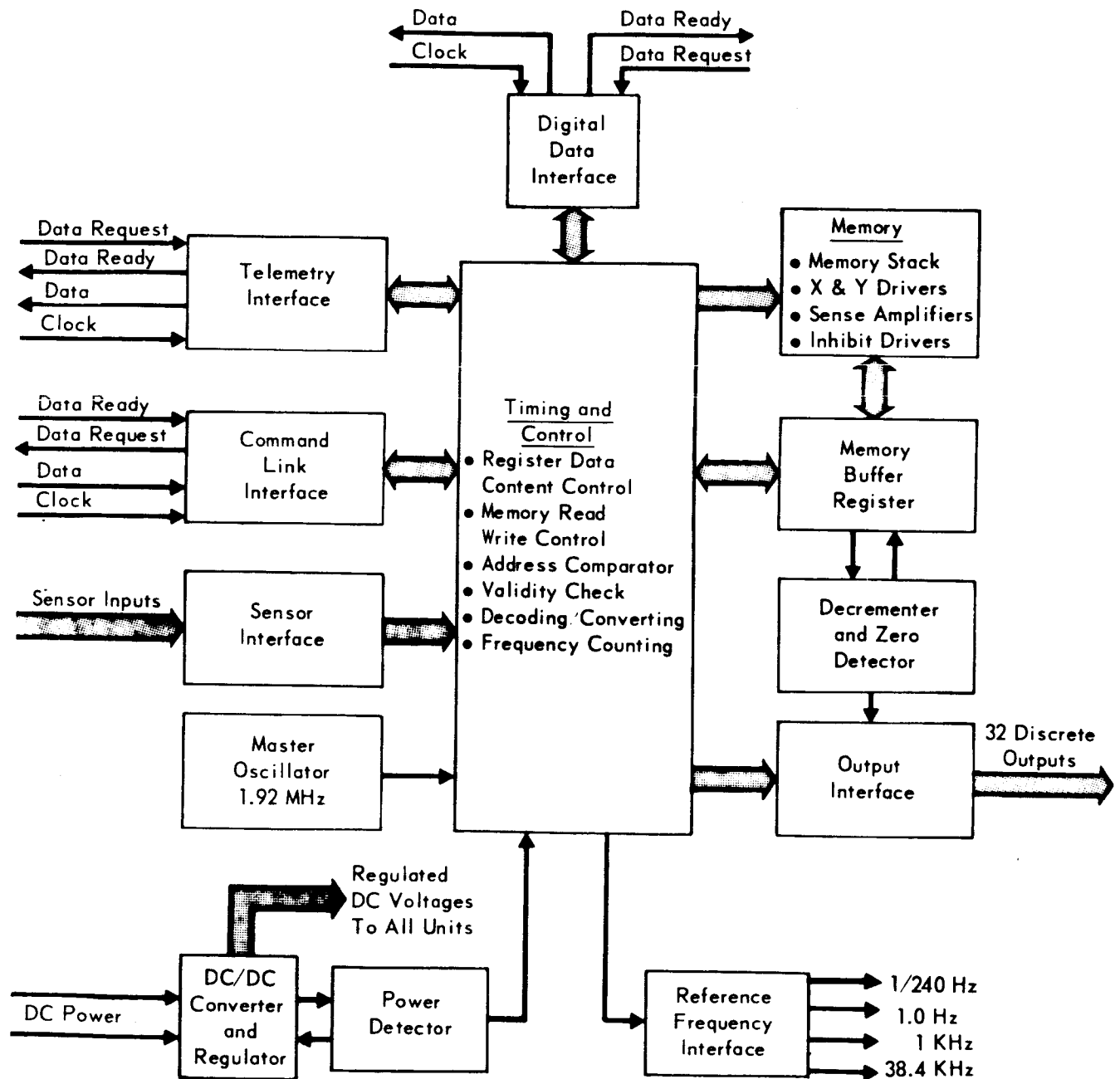


Figure 3.1.2-1

SURFACE LABORATORY SEQUENCER & TIMER RELIABILITY MODEL

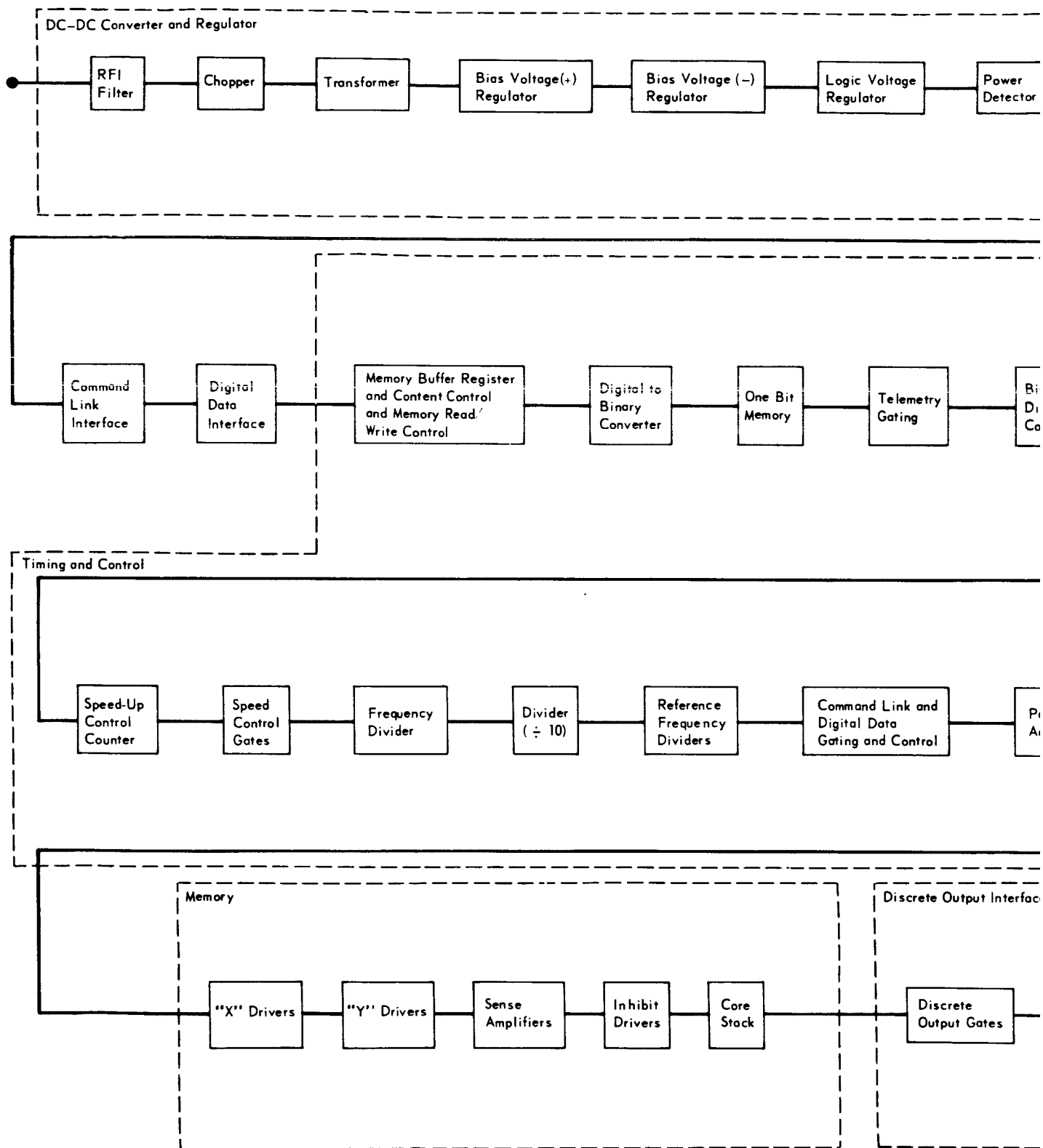
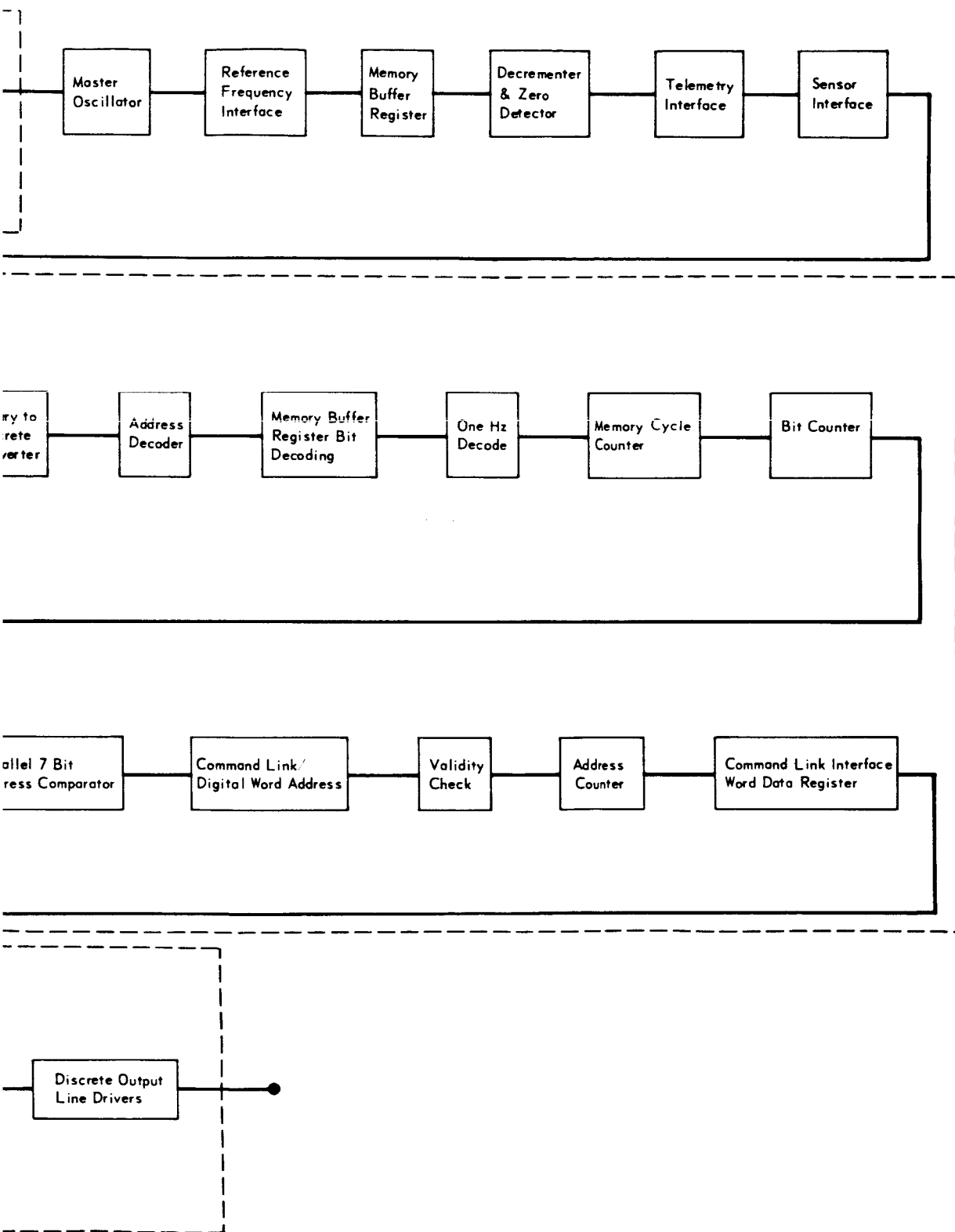


Figure 3.1.2-2

2-4-1

3



2-4-2

Figure 3.1.3-1, was used for all other assemblies and/or components. Average failure rates were used for the different component parts with no attempt to predict part derating or environmental stresses internal to the assembly. To insure good relative comparisons of the estimated reliability of competing concepts, a list of standard failure rates for electrical and electronic piece parts was established and used for all parts count estimates. This same technique can be extended to include the effects of part derating and operating environments as the detailed design of the assemblies materializes. The part count technique provides an effective tool for determining areas in which reliability can be improved by effective part derating or by incorporating redundancy within the assembly.

3.1.4 Subsystem Reliability Estimate - The final step in arriving at a subsystem or concept quantitative reliability estimate was to combine the above elements. Figure 3.1.4-1 illustrates one technique for arriving at the subsystem estimate. A modified time (t_m) was determined for each subassembly by applying the modifying factors as previously shown in Figure 3.1.1-1 to the mission duty cycle of the subassembly. This time (t_m), for time dependent items, was then multiplied by the failure rate of the item to find the mission failure rate for each item. The summation of these mission failure rates gives the subsystem mission failure rate. The subsystem mission reliability was determined by use of the formula

$$R = e^{-\lambda t_m}$$

3.2 RELIABILITY ESTIMATE LIMITATIONS - The limitations of quantitative reliability estimates must be recognized if results are to be interpreted properly. Quantitative estimates for system and subsystem reliability made during this concept definition phase have accuracy limited by the level of design maturity. Quantitative reliability estimates are a valuable input to early design decisions and will become more and more significant as the design becomes more detailed. The emphasis will gradually shift from comparative estimates toward predictive estimates as the design evolves, with the failure mode, effect and criticality analyses being of primary importance in design shaping.

3.3 SUMMARY OF RELIABILITY ESTIMATE RESULTS - The primary use of the quantitative reliability estimates has been for comparative evaluation of competing subsystem concepts rather than to predict the actual reliability of a given concept or the preferred concept. A quantitative reliability estimate was a standard input to major design trade studies and was a major factor in many decisions. The estimates have served to highlight areas for reliability improvement. The reliability

**PARTS COUNT ESTIMATE
SURFACE LABORATORY SEQUENCER AND TIMER
MEMORY SUBASSEMBLY**

COMPONENT	QUANTITY (n)	FAILURE RATE $\lambda \times 10^6/\text{hr}$	$(n)\lambda \times 10^6$
"X" Drivers			
Integrated Circuits	4	.10	.400
Transistors, Silicon	32	.05	1.600
Resistors, Carbon	64	.001	.064
"Y" Drivers			
Integrated Circuits	2	.10	.200
Transistors, Silicon	16	.05	.800
Resistors, Carbon	32	.001	.032
Sense Amplifiers			
Integrated Circuits	24	.10	2.400
Inhibit Drivers			
Transistors, Silicon	48	.05	2.400
Resistors, Carbon	96	.001	.096
Core Stack			
Cores	3072	.003	9.216
Subassembly Failure Rate = $\Sigma n \lambda = 17.208 \times 10^{-6}$			

Figure 3.1.3-1

RELIABILITY ESTIMATE
SURFACE LABORATORY SEQUENCER AND TIMER

COMPONENT OR SUBASSEMBLY	t_m (HOURS)	FAILURE RATE $\lambda \times 10^6$ / HOUR	$\lambda t_m \times 10^6$ ($-\ln R \times 10^6$)
DC-DC Converter and Regulators	173	3.127	541
Memory	173	17.208	2977
Crystal Oscillator	173	.833	144
Memory Buffer Register	173	3.000	519
Sensor Interface	173	.416	72
Decrementer and Zero Detector	173	.500	87
Telemetry Interface	173	.104	18
Command Link Interface	173	.104	18
Digital Data Interface	173	.104	18
Reference Frequency Interface	173	.104	18
Timing & Control	173	18.200	3149
Power Detector	173	.043	7
Output Interface	173	4.064	703
$\Sigma = 8270$			
$R = e^{-\Sigma \lambda t_m} = .9918$			

Figure 3.1.4-1

estimates were a necessary input to the reliability versus weight and effectiveness analysis.

A quantitative reliability estimate of the selected Surface Laboratory configuration has been computed and is presented in Figure 3.3-1. This estimate indicates that the telecommunication subsystem, electrical power subsystem and experiments will collectively have the greatest influence on Surface Laboratory reliability.

VOYAGER SURFACE LABORATORY EQUIPMENT RELIABILITY ESTIMATE SUMMARY

SUBSYSTEM	MISSION RELIABILITY ESTIMATE
Telecommunication	.920
Telemetry	
Radio	
Antenna	
Command	
Data Storage	
Instrumentation	
Science Data	
Electrical Power	.985
Power Switching and Logic	
Battery Chargers	
Main Batteries	
Sequencer and Timer	.991
Thermal Control	.993
Staging	.999
Experiment Deploy and Release	
Experiments	.871
Surface Laboratory Equipment Reliability	.776

Figure 3.3-1

SECTION 4

RELIABILITY PROGRAM REQUIREMENTS

The Phase B study has revealed several reliability program elements which must receive increased major emphasis throughout the program. These elements are: 1) Failure modes, effects, and criticality analysis, 2) Specially planned parts and materials program, 3) Positive failure analysis, evaluation and corrective action, and 4) Comprehensive design reviews.

4.1 FAILURE MODE, EFFECTS, AND CRITICALITY ANALYSIS - FMECA is a powerful reliability technique for highlighting potential design weakness. It must be a primary continuing reliability task performed concurrently with the detail design and operational contingency analysis. The FMECA carried to the detail level provides the basis for design considerations which minimize mission failures or degradation.

4.2 PARTS AND MATERIALS PROGRAM - The decontamination, sterilization, and long-life requirements demand the need for a specially planned parts and materials program. This program must provide for the selection, testing, and control of parts and materials to assure that the parts and materials meet these environmental and life requirements and do not compromise equipment reliability.

4.3 FAILURE EVALUATION - "Failures" or performance irregularities must be expeditiously and positively identified, analyzed, and corrective action taken. This assures that no problem remains unidentified and immune to maximum corrective effort.

4.4 DESIGN REVIEWS - In depth design reviews must be conducted on all elements of the Surface Laboratory System. The design review process must also place equal emphasis on the review of the operational support equipment compatibility with the system and/or subsystems. The compatibility must be clearly evaluated by design review to assure that the interface design of the operational support equipment and flight equipment will not compromise the launch constraints.

SECTION 5

COMPONENT PART RELIABILITY

Recognizing that system reliability is influenced by the characteristics and application of the component parts, we have devoted our Phase B effort to: (1) determining the elements of a realistic component part plan, and (2) initiating certain elements of this plan.

The elements of the plan are:

- a. An Approved Parts List (APL) listing those parts demonstrating ability to meet VOYAGER Capsule Bus requirements.
- b. Specification control for all parts.
- c. Parts Application Manual for electrical and mechanical parts.
- d. Parts Test Program.
- e. Traceability program.

During Phase B we have begun work on elements a, b, c, and d as reported in the paragraphs immediately following.

5.1 APPROVED PARTS AND MATERIALS LIST - During Phase B, a preliminary Approved Parts List (APL) was issued and used by the design functions as a guide where part information was required to conduct meaningful implementation studies. The data used to generate the list were taken from JPL Document ZPP-2010-SPL-C, "Electronic Parts Sterilization Candidates for Spacecraft Application." In addition an Approved Materials and Processes List was prepared based on data available to us from many sources and from in-house testing. Only those parts, materials and processes which exhibited evidence of meeting the VOYAGER Flight Capsule requirements were included in these lists. These two lists are McDonnell Douglas Reports F189 and E936, respectively.

The APL includes tabulations of specific electrical and mechanical parameters to aid the design groups in proper part selections for particular applications. The APL subdivides the parts into three categories.

- a. High Reliability - These parts are VOYAGER preferred parts which have been subjected to long term failure rate life tests and have established low failure rates.
- b. Preferred Parts - These parts are tested and qualified for use in the VOYAGER Flight Capsule environment.

- c. Nonstandard - These parts are Special or Limited application, and receive specific testing and justification for use.

It is recognized that modification to the Approved Parts, Materials and Processes Lists will be required as the VOYAGER Program progresses. The continuing component part reliability program plan for the Phase C and D effort is detailed in Part C, Section 10 of Volume VI.

5.2 SPECIFICATION - Several special specifications were produced for the VOYAGER Flight Capsule Program during the Phase B study in preparation for the Phase C design effort. These specifications delineate the part requirements and the approved sources of supply. Approved sources of supply candidates were selected from JPL Document ZZP-2010-SPL-C.

To minimize duplication, a two level specification system is used as described below:

- a. General Specification - A specification covering the general requirements for generic types or families of parts.
- b. Detail Part Drawings - A specification delineating the detail requirements for a specific part.

Examples of existing specifications are as follows:

- a. General Specification, VOYAGER Flight Capsule, Semiconductors, Transistors, Diodes and Integrated Circuits (207-780003)
- b. Detail Part Drawing, Integrated Circuit, Flip-Flop, RST (207-780007)
- c. Detail Part Drawing, Semiconductor, Diode, General Purpose, Power, Silicon (207-780004)
- d. General Specification, VOYAGER Flight Capsule, Capacitors, Fixed (207-780005)
- e. Detail Part Drawing, Capacitor, Fixed, Ceramic (207-780009)

The Semiconductor General Specification and the Integrated Circuit Detail Part Drawing are included in Appendix (A) as examples.

The procedure established for the issuance of additional specifications is given in the component part, material and processes program plan, Part C, Section 10 of Volume VI.

5.3 APPLICATION MANUAL - Part parameter control alone is not sufficient to assure satisfactory operation of the part. Our approach for the VOYAGER Flight Capsule System places equal emphasis on use of the best part and best use of the part. In conjunction with the Approved Parts List, a Parts Application Manual

was initiated in Phase B as a guide for the design groups, and is discussed in more detail in Part C, Section 10 of Volume VI. The following information as a minimum is included in the manual:

- a. Function of the part
- b. Application considerations and limitations
- c. Electrical characteristics
- d. Environmental limitations
- e. Failure modes
- f. Failure rates
- g. Physical properties
- h. Packaging, mounting and handling limitations

5.3.1 Electrical Considerations - In order to assure high reliability designs, conservative derating of electrical stress for component parts is necessary. These derating factors were established and included in the initial issue of our applications manual. The following are examples of derating factors used:

- a. Integrated Circuits - Fan-in and fan-out shall be such that the power dissipation shall not exceed 50 percent of maximum rating.
- b. Power Transistors - Power dissipation shall not exceed 30 percent of rated maximum, base and emitter currents shall not exceed 75 percent of rated maximum, and voltages shall not exceed 75 percent of rated maximum.
- c. Wire Wound Resistors (1 percent tolerance and up) - Power dissipation shall not exceed 50 percent of rated maximum.

These derating values are generic, and further evaluation is required for each individual part within the general part category.

5.3.2 Mechanical Considerations - Consistent with the level of detail design existing in the Phase B study, a review of the packaging, mounting, and environmental factors affecting parts was performed and comparisons made with the part limitations. The following items were considered in the review:

- a. Thermal inertia
- b. Thermal conductivity
- c. Thermal radiation on adjacent parts
- d. Vibration
- e. Encapsulation
- f. Mounting
- g. Interconnection

This type of review must continue in depth as the design proceeds into Phase C and D.

The results of the review and results of mechanical and process tests provided the data for proper parts applications, and was reflected in the Approved Materials and Processes List and in the Parts Application Manual.

5.4 TESTING - Tests were conducted prior to and during Phase B to evaluate the effects of heat sterilization and decontamination cycles and shock. These tests, involving thirteen part types, resulted in very few failures.

- a. Power diodes failed due to dessicant liberating moisture during the heat cycle. Although a large percentage of one diode type group exhibited high reverse current leakage, none of the failures resulted directly from the sterilization or shock environment.
- b. Powdered iron core inductors failed when subjected to shock beyond that expected in the Flight Capsule.

For a summary discussion of the above part testing see Part B, Section 1.1 of Volume VI.

Several insulation and encapsulation materials are presently being evaluated in our laboratories sterilization temperature, operating temperature and at a pressure of 10^{-10} Torr to assure that outgassing and sublimation will not create hazards to the part or surrounding parts.

5.4.1 Qualification - During Phase B, we have examined the required qualification testing to assure that all parts are suitable for the VOYAGER Flight Capsule requirements. Qualification testing must be performed and will include all environments deemed necessary to qualify the parts. The particular number of qualification samples will be selected in accordance with individual parameters, environments and failure rate requirements. Qualification environment will include heat sterilization temperatures, decontamination (ETO) atmospheres, shock, humidity, vibration, acceleration and others necessary to assure compliance with VOYAGER requirements. Part parameter limits consist of attribute as well as variables data. The required testing is reflected in the part specifications.

The amount and degree of testing required is tempered by information acquired during previous programs or received from cooperating agencies, such as the Interservice Data Exchange Program (IDEP) and Parts Reliability Information Center/ Apollo Parts Information Center (PRINCE/APIC).

processes and inspection points are identified by the applicable internal specification including revision date. Subsequent to acceptance of the flow chart, changes must be reported by the supplier before shipment of parts incorporating process changes. Although this requirement is not expected to prevent changes in the manufacturer's processes, it establishes a baseline upon which an evaluation can be made of process changes as they occur on parts procured after the initial qualification of the manufacturer. Single lot procurement is used where practicable by the subcontractors. (All parts required for the system are purchased at one time and are from the same lot as the qualification sample.)

5.5.2 Subcontractor - Subcontractors are subject to the same controls as those used internally at the prime contractor. The subcontractors are monitored to ensure conformance. Part selection by the subcontractor is limited to those parts included in the VOYAGER Approved Parts List established and maintained by the prime contractor. In order to use parts not on the approved list, a procedure for revising the Approved Parts List is discussed in Part C, Section 10 of Volume VI.

Subcontractors are required to keep McDonnell apprised of all part application and selection activities. This information, coupled with the prime contractor's own part experience, is disseminated to all subcontractors to minimize parallel effort and encourage consideration of parts already proven by test.

5.5.3 Traceability - Traceability requirements provide for the identification of a particular piece part or group of parts through all phases of assembly and testing. All parts will be identified with either a serial number or lot number. Serial numbers will be used on critical parts only and will be minimized to the greatest extent possible. The traceability document (207-780002) prepared during our Phase B activity, lists the following parts as requiring serialization.

- Transistors - power, field effect and RF

- Diodes - microwave, varactor, controlled rectifiers

- Integrated circuits

- Tubes

- Crystals

All other parts will be identified by lot number for traceability.

Any failures or deficiencies are isolated to the part level and proper corrective action taken. All failed parts are subjected to failure analysis to determine failure modes. After failure modes are identified, an analysis of the test data will enable determination of the proper corrective action.

APPLICATION		QTY/ ASSY	FIN. ART.	REVISIONS			
NEXT ASSY	USED ON			LTR	DESCRIPTION	DATE	APPROVED
				A	Added Paragraph 5.5	18 July 1967	<i>[Signature]</i>
CODE NO.	PART NO.	DRAWING OR SPECIFICATION	NOMENCLATURE OR DESCRIPTION	STOCK		MATL	
				VENDOR NAME - ADDRESS			
PARTS LIST							
LIMITS UNLESS NOTED .x = $\pm .1$.xx = $\pm .03$.xxx = $\pm .010$		DRAWN <i>[Signature]</i> 16 June 67		MCDONNELL ST. LOUIS, MO. GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS			
		CHECK					
		STRENGTH					
		GR ENGR					
		APPD					
FINISH SPEC		PRO ENGR <i>[Signature]</i>		SIZE A	CODE IDENT NO. 76301	207-780003	
CONTRACT NO.		CUSTOMER		SCALE		SHEET 1 of 14	

MAC 1197A (REV 24 NOV 65)

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

1. SCOPE

- 1.1 This specification establishes the general requirements for semiconductor, transistors, diodes and integrated circuits suitable for use in Voyager Flight Capsule application. Specific requirements for a particular semiconductor device are listed in applicable detail part drawings.

2. APPLICABLE DOCUMENTS

- 2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-S-19500 Semiconductor Devices, General Specification

MIL-G-45204 Gold Plating (Electrodeposited)

National Aeronautics and Space Administration

NPC 200-3 Inspection system provisions for Suppliers of Space Materials, Parts, Components and Service

McDonnell

207-780011 Visual Inspection Criteria, Voyager Flight Capsule Semiconductor Devices

STANDARDS

Military

MIL-STD-130

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-750 Test Methods for Semiconductor Devices

MIL-STD-1276 Weldable Leads for Electronic Component Parts

REVISED:

DRAWN	<i>[Signature]</i>	APPRD			GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS. MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
CHECK		APPRD				DRAWING NO.		SHEET	
APPRD		APPRD				207-780003		2	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

2

3. REQUIREMENTS

3.1 Conformance. The individual types of semiconductors shall conform to the detailed requirements specified in the applicable McDonnell detail part drawing and this specification.

3.1.1 Conflicting Requirements. In the event of conflict between this specification and the documents referenced herein, the order of precedence shall be as follows:

- a. Purchase Order
- b. Applicable McDonnell Detail Part Drawing
- c. This Specification
- d. NASA/Government Specification
- e. Military Specifications.

3.1.2 Reference to Detail Part Drawing. For purposes of this specification, when the term "specified" or "as specified" is used without reference to a specific location the intended reference is to the McDonnell detail part drawing.

3.2 Qualification. Semiconductor devices furnished under this specification shall be a product which has been tested and passed the qualification and acceptance tests specified herein.

3.3 Request for Deviation. Any change from the requirements of this specification, or applicable documents listed herein, shall be considered a deviation. Request for a deviation shall be submitted in writing to McDonnell. Materials and processes used in the fabrication and assembly of the semi-conductor qualification test samples shall be documented at the time of qualification and any subsequent material and process changes for these parts shall be forwarded to McDonnell. Manufacturer shall obtain McDonnell approval before shipment of any parts for Voyager Flight Capsule application containing such changes.

3.4 Leads and Terminal Material/Finish. The lead material used shall conform to MIL-STD-1276, as applicable. The leads shall not show evidence of base metal corrosion after completion of the environmental tests specified herein.

The finish of the semiconductor case shall exhibit no peeling or cracking of the body surface area, of the marking, or of the color coding after completion of all tests performed thereon.

3.5 Mechanical Characteristics.

The mechanical characteristics of the semi-conductor shall be as specified herein and in the detail part drawing.

REVISED:	DRAWN		APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.	
	CHECK		APPRD			DRAWING NO.				SHEET
	APPRD		APPRD			207-780003				3

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

- 3.5.1 Lead and Terminal Test. Each semiconductor shall be capable of withstanding the pull test, bend test, twist test, torque test and soldering heat test as specified in the detail part drawing without physical damage to the leads, terminals or the semiconductor body, and without degradation of the semiconductor electrical characteristics.
- 3.6 Electrical. Semiconductor electrical performance characteristics shall be as specified in the detail part drawing. Semiconductors furnished to the requirements of this specification shall have met the qualification and acceptance inspections specified in 4.2 and 4.3.
- 3.6.1 Maximum Ratings. Semiconductor maximum ratings shall be as specified in the detail part drawing.
- 3.7 Environmental. Semiconductors shall operate within the limits as specified in the detail part drawing before and after being subjected to the environmental conditions outlined in 3.7.1 thru 3.7.11.
- 3.7.1 Sterilization and Decontamination. Semiconductors shall operate within the limits as specified in the detail part drawing after being subjected to heat sterilization and ethylene oxide decontamination.
- 3.7.1.1 Heat Sterilization. Sterilization shall consist of six separate cycles of heat at a maximum temperature of 135°C. in a nitrogen atmosphere. The nitrogen shall have an initial dew point prior to heating of no greater than minus 54°C and the gas shall possess a purity so that no more than 50 parts/million of extraneous products shall be contained within the gas. The total time of application of the environment is 96 hours per cycle (the time at the stabilized 135°C is 92 hours per cycle). Each item shall be at an initial temperature of 20-25°C prior to the beginning of each cycle. Performance tests and other evaluation criteria for determining the effects of the environment on the units shall be as specified in the detail part drawing.
- 3.7.1.2 Decontamination. Devices shall meet the end point test limits of group B sub-group 2 before and after the ethylene oxide decontamination test. This test shall consist of six (6) separate cycles at a temperature of 50 ± 5°C and an environment of 88% Freon and 12% ethylene oxide at 50% relative humidity and a concentration of 600 m.g./liter of gaseous atmosphere. A test cycle shall consist of:
- 1 hour during which the temperature is increased to 50 ± 5°C and the air atmosphere is maintained at 50% R.H.
 - 21 to 24 minutes during which the atmosphere is evacuated to 70 torr.

REVISED:	DRAWN	APPRD			GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS. MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK	APPRD				DRAWING NO.		SHEET	
	APPRD	APPRD				207-780003		4	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

3.7.1.2 (Continued)

- c. 27.5 hours during which the atmosphere is maintained at 50% R.H. with a concentration of 600 m.g./liter of 88/12 mixture of Freon 12 and ethylene oxide.
- d. 15 minutes - evacuate to 70 torr. and permit temperature to fall.
- e. 45 minutes - permit temperature to fall to 20-25°C by introducing ambient air.

3.7.2 High Temperature Storage. Semiconductors shall operate within the limits specified in the detail part drawing after being tested in accordance with Method 1031.1 of MIL-STD-750. The ambient temperature for this test shall be 200°C minimum.

3.7.3 Temperature Cycling. Semiconductors shall operate within the limits as specified in the detail part drawing after being tested in accordance with Method 1051.1 of MIL-STD-750 (Test Condition C, Method 107 of MIL-STD-202)

3.7.4 Moisture Resistance. Semiconductors shall operate within the limits as specified in the detail part drawing after being tested in accordance with Method 1021.1 of MIL-STD-750 (Method 106, MIL-STD-202, omitting Step 7B and the initial 24 hour soak period.)

3.7.5 Hermetic Seal. Semiconductor shall not exhibit leak rates in excess of 1×10^{-8} atm - cc per second when tested in accordance with 4.3.3.4.

3.7.6 Shock. Semiconductors shall be capable of operation within the limits as specified in the detail parts drawing after being tested in accordance with Method 2016.1 of MIL-STD-750. A total of 30 impacts shall be applied in each of three mutually perpendicular planes (10 impacts each plane).

3.7.7 Vibration. Semiconductors shall be capable of operation within the limits specified in the detail part drawing when subjected to the Vibration Test Method 2046 of MIL-STD-750.

3.7.8 Low Temperature Operating. Semiconductors shall be capable of operating within the limits as specified in the detail part drawing after stabilizing parts at an ambient temperature -63^{+0}_{-5} °C for this test.

3.7.9 Acceleration. Semiconductors shall be capable of operation within limits as specified in the detail part drawing after subjected to a constant acceleration of 20,000g's per Method 2006 of MIL-STD-750, with the semiconductors so oriented that the acceleration vector is in the direction (normally in Y_1 orientation only) most likely to produce mechanical/bonded interconnection failure.

REVISED:

DRAWN	<i>J.M.</i>	APPRD			GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
CHECK		APPRD				DRAWING NO.		SHEET	
APPRD		APPRD				207-780003		5	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

- 3.7.10 Vacuum. Semiconductors shall be capable of operation within limits as specified in the detail part drawing after subjected to a pressure of 10^{-5} Torr (mm of mercury) at a temperature of $-65^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ for a period of 24 hours. No degradation or deteriorations of seal shall occur.
- 3.7.11 Operating Life. Semiconductors shall be capable of operation within limits as specified in the detail part drawing when tested in accordance with Method 1026.1 of MIL-STD-750.
- 3.8 Failure Rate. Semiconductors shall have a failure rate as specified in the detail part drawing.
- 3.9 Physical Dimensions. The physical dimensions of the semiconductors shall be as specified in the detail part drawing.
- 3.10 Marking. Manufacturer shall permanently and legibly mark each part in accordance with MIL-STD-130 with the following:
- Manufacturer's Name or Symbol
 - Lot or Serial Number (as specified)
 - Polarity (as applicable)
- 3.11 Part Identification/Traceability. Two-way traceability, that is, from a particular semiconductor to a known lot and from a known lot to a particular semiconductor from that lot shall be maintained when specified in the detail part drawing. This information shall be immediately available to McDonnell upon request. Part identification for this two-way traceability shall include part serialization per 3.11.1. Where this two-way traceability defined above is not required to a particular semiconductor, lot identification shall be provided as a minimum per 3.11.2.
- 3.11.1 Part Serialization. Semiconductors when required shall be marked with an individual serial number. The serial number shall consist of a three digit number ranging from "000" to "999" for each semiconductor part number. Deviations to this range of serial numbers will be considered and approved (by McDonnell) as justified. The serial numbers shall identify each semiconductor with the applicable recorded data and manufacturer's lot or lots. No serial number shall be duplicated for semiconductors with the same part number. The serial number shall be printed on the semiconductor body (or as specified on the detail part drawing).

REVISED:	DRAWN	<i>[Signature]</i>	APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780003		6	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

3.11.2 Lot Identification. Each semiconductor not requiring part serialization shall contain the manufacturer's lot identification number which shall identify the semiconductor with the applicable recorded data for a particular group or lot of parts included under the identifying lot number. A manufacturer's lot is defined as a quantity of parts produced in one week or less, from a single production line using the same design, materials, manufacturing processes and specifications, and presented to inspection for tests at the same time. A McDonnell Voyager Flight Capsule lot shall be the group of parts to be subjected to the acceptance inspection specified in 4.3. The lot of parts purchased to this specification shall be from a single manufacturer's lot except where deviations have been submitted and approved.

3.12 Documentation and Data Submittal. The variables data listed under (a) and (b) below shall be submitted with the semiconductor. In the addition to the parameter values, the punched card shall contain the individual semiconductor lot number or serial number, McDonnell part number, date, etc. Data recorded regarding a rejected McDonnell lot shall be forwarded to the McDonnell Company. A copy of all required data shall be kept on file by the manufacturer for a period of at least five years from the date of delivery of the components. At the completion of the test specified in 4.3.4 the component inspection report form per Figure 1 shall be completed and submitted with each shipment of parts and data cards. Data submittal shall include the following:

- (a) Variables data on each of the critical parameters specified at the 100% level for each semiconductor given the acceptance inspection per 4.3.
- (b) Variables data on all parameters specified in the applicable detail part drawing taken during final electrical measurements (post burn-in) final electrical inspection (Group A inspection).
- (c) Data on all parameters specified in the applicable detail part drawing following the Group B environment test per 4.3.7.

4. RELIABILITY AND QUALITY ASSURANCE PROVISIONS

4.1 General. Implementation of the quality assurance provisions specified herein shall be in accordance with the applicable requirements of NPC 200-3. The examination and testing of semiconductor devices shall be classified as follows:

- (a) Qualification Inspection
- (b) Acceptance Inspection

REVISED:	DRAWN	APPRD			GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK	APPRD				DRAWING NO.		SHEET	
	APPRD	APPRD				207-780003		7	

MAC 1202A (REV 4 AUG 61)

APPROVED JUNE 1967 REVISED

CODE IDENT NO. 76301

4.2 Qualification Inspection. Qualification tests are those tests performed on devices to verify conformance to all requirements of this specification. Unless otherwise specified the total qualification test sample shall consist of 60 specimens which have not been previously subjected to life testing. The specimens shall be subjected to the 100% Process Preconditioning and Screening, the group A and B tests and the failure rate life test of the detail specification, as follows: All specimens shall be subjected to 100% Process-Preconditioning and Screening, Group A tests and the Failure Rate Life Test. For group B, testing the specimens shall be divided into three groups of 20 specimens each. The first group shall be subjected to the tests specified in Sub-group 1 and 2 of Group B; the second group shall be subjected to the tests specified in sub-group 3 of Group B; the third group shall be subjected to the tests specified in the remaining sub-group of Group B.

4.2.1 Post Qualification Test End Points - The end point tests specified in the individual detail specification shall be performed after the intermittent life test and after each Group B sub-group test where end points are specified. Failure of one device in one or more tests of a given sub-group will be charged as a single failure. Failures in excess of those allowed for each group shall constitute qualification failure. Devices subjected to qualification inspection may be shipped except for destructive tests which include solderability, soldering heat, moisture resistance, terminal strength, salt atmosphere and salt spray. Compliance with these requirements qualifies the manufacturer for the following 12 month period provided design changes are not made during this time.

4.3 Acceptance Inspection. Acceptance inspection consists of the following inspections:

- (a) Dimensional
- (b) Visual
- (c) 100% Process-Preconditioning and Screening (Burn-in)
- (d) Group A Electrical
- (e) X-ray (diodes and transistors); Color (Micro-Photographs (Integrated Circuit - see 4.3.7)
- (f) Group B Environmental

Electrical measurement methods shall conform to the applicable requirements of MIL-STD-750. The McDonnell Outside Production Quality Assurance Department shall be notified at least one week in advance of the scheduled date for performing acceptance inspection on semiconductors purchased to this

REVISED:	DRAWN	<i>[Signature]</i>	APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.			
	APPRD		APPRD			207-780003			
						SHEET 8			

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

4.3 Acceptance Inspection (Continued)

specification. Lots which are rejectable via sampling inspection may be screened 100 percent for the failing characteristics and may then be resubmitted one time to inspection. In addition, McDonnell reserves the right to sample test each 100 percent inspection requirement for each lot to a 2 percent LTPD level and reject any lot that does not meet the requirement. The 100 percent process-preconditioning and screening tests in 4.3.3 are not required to be repeated when they are already included in the manufacturers normal production processing.

4.3.1 Dimensional Inspection. Dimensional inspection shall be performed on the semiconductors at an LTPD of 15 percent as specified (Ref. Table I for minimum requirements).

4.3.2 Visual Inspection. Visual inspection shall be performed at a 100 percent level as specified in the detail part drawing and specification 207-780011 as applicable. Semiconductors not meeting the visual inspection criteria shall be rejected. Integrated circuits shall be micro-photographed in color, per 4.3.7.

4.3.3 100% Process-Preconditioning and Screening. The semiconductors in the lot shall be subjected to the following tests. The test methods employed shall be in accordance with MIL-STD-750. The environmental tests shall be performed prior to the burn-in inspection of 4.3.3.7. Test 4.3.3.1 thru 4.3.3.5 shall be performed in the following sequence.

4.3.3.1 High Temperature Storage. The semiconductors shall be subjected to a high temperature storage per MIL-STD-750, Method 1031.1 at a temperature of 200°C minimum.

4.3.3.2 Temperature Cycling. The semiconductors in the lot shall be temperature cycled in accordance with MIL-STD-750, Method 1051.1 (MIL-STD-202, Method 107B, Test Condition C).

4.3.3.3 Constant Acceleration. The semiconductor shall be subjected to constant acceleration in accordance with MIL-STD-750, Method 2006. A minimum centrifugal acceleration of 20,000g's shall be applied, with the semiconductor so oriented that the acceleration vector is in the Y_1 axis direction (or that axis which will most likely produce mechanical bonded interconnection failure).

4.3.3.4 Hermetic Seal Tests

REVISED:	DRAWN	APPRD	GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS		REV	MODEL	VOL	ASSY NO.
	CHECK	APPRD	MCDONNELL		DRAWING NO.			SHEET
	APPRD	APPRD	ST. LOUIS, MO.		207-780033			9

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

- 4.3.3.4.1 Gross Leaks. Each semiconductor shall be tested in accordance with MIL-STD-202, Method 112, Test Condition A. Any indication of air escapement from within the semiconductor case shall be cause for device rejection.
- 4.3.3.4.2 Fine Leak. Each semiconductor and metal cased diode shall be tested in accordance with MIL-STD-202, Method 112, Test Condition C, Procedure IIIA or IIIB. Semiconductors with leak rates in excess of 10^{-8} atm-cc per second shall be rejected.
- 4.3.3.4.3 Glass Diode Seal Test. Each glass cased diode shall be subject to an hydraulic pressure of 100 psig in a solution of isopropyl alcohol with coloring dye for two hours. Following pressurization, rinsing, and drying, each diode shall receive a reverse current test and an operating vibration test (see 4.3.3.5). The time interval between pressurization test completion and start of the electrical tests shall be at least two hours, but not to exceed eight hours. Diodes exhibiting reverse leakage in excess of the limits specified in the detail part drawing, ionic contamination (indicated by mobile hysteresis progressing in the high current direction) or dye penetration shall be rejected.
- 4.3.3.5 Operating - Vibration Test. Where specified, each semiconductor shall be subjected to a simple harmonic vibration having a minimum of 0.1 inch double amplitude displacement at a frequency of 60 ± 2 cps for a minimum period of 30 seconds. During vibration continuously monitor the reverse characteristic, swept at 60 cps, to the inverse current or voltage specified. Devices displaying flutter, drift, dynamic instabilities or shift in trace shall be rejected.
- 4.3.3.6 Pre-Burn-In Electrical Measurements. Each semiconductor in the Voyager Flight Capsule lot shall be subjected to electrical measurements of the critical parameters (100% level) specified in the applicable detail part drawing. All variable data shall be recorded.
- 4.3.3.7 Burn-In Operational Life Test. Each semiconductor shall be subjected to a burn-in (operational life test) at the electrical level and temperature for 168 hours as specified in the detail part drawing.
- 4.3.3.8 Post Burn-In Electrical Measurements. Same as pre-burn electrical measurements except that limits including delta or parameter incremental changes shall be as specified in the detail part drawing.

REVISED:	DRAWN	<i>[Signature]</i>	APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780003		10	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

- 4.3.4 **Group A Electrical Inspection.** Group A electrical inspection shall be performed by lot sample as specified in the Group A inspection, Table II of the applicable detail part drawing. The minimum sample size to assure a Lot Tolerance Percent Defective (LTPD) specified with 90% confidence for various failure acceptance numbers (a) is shown in Table I of this specification. The rejection number (r), equals $a + 1$. The acceptance sample size required to assure the specified LTPD shall be selected from Table I of this specification by the manufacturer.
- 4.3.5 **Final Visual Inspection.** Final visual inspection shall be performed at a 100 percent level. Only those semiconductors which meet the visual inspection criteria specified shall be shipped.
- 4.3.6 **X-ray Examination.** Unless otherwise specified in the detail part specification, each transistor and diode not permitting internal visual inspection shall be photographed using an X-ray machine of sufficient power to show the internal construction. Integrated circuits shall be micro photographed per 4.3.7. Sufficient definition is achieved when free particles of solder or other foreign matter one mil in diameter can be determined. A series of x-ray photographs shall be taken perpendicular to the longitudinal axis (in two mutually perpendicular planes). The x-ray photographs shall be identified to assure traceability to the individual semiconductor when part serialization is required. Acceptance criteria shall be in accordance with McDonnell 207-780011.
- 4.3.7 **Photographic Records.** Each integrated circuit shall be photographed at 100X magnification, in color, just prior to final seal. Photographs shall be identified with device part number and serial number and delivered with the devices. Photographs shall have sufficient resolution to show scratches in the conductor paths, particle inclusions, etc.
- 4.3.8 **Group B Environmental Inspection.** Semiconductor parts from the same lot to be shipped per this specification shall be sample tested as specified in the Table III Group B Inspection of the applicable detail part drawing.
- 4.4 **Failure Accountability.** A complete accounting of failures and modes (i.e., human error, instrumentation, parametric, or catastrophic) shall be submitted to McDonnell on all accountable and unaccountable failures occurring during acceptance inspection.
5. **PREPARATION FOR DELIVERY**
- 5.1 **Unit Packaging.** The semiconductors shall be individually packaged to protect the case and leads during shipment. Each unit package shall be clearly marked as to semiconductor types, serial number and lot number. Package design shall be subject to McDonnell approval prior to usage by the manufacturer.

REVISED:	DRAWN	<i>H 127</i>	APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780003		11	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

- 5.2 **Packaging of Shipping Containers.** The unit packages shall be packed in the shipping containers in a manner to provide maximum protection from shock and vibration during transit; and in the order of ascending serial number or groups of serial numbers, to facilitate and minimize handling subsequent to delivery.
- 5.3 **Marking of Shipping Containers.** Each shipping container shall be marked with the manufacturer's name, part designation number, date code and lot number.
- 5.4 **Shipping/Data Documentation.** The certificate of compliance and the data required in 3.12, 4.3 and 4.4 shall accompany each shipment of parts. The IBM cards shall be punched and interpreted, and packed in numerical sequence in suitable boxes, labeled as to component type, lot number and serial number range. The data cards for rejected parts shall be segregated from the cards for accepted parts and all cards submitted with the lot. For integrated circuits the photographs required in Paragraph 4.3.7 shall also accompany the shipment.
- 5.5 **Process Flow Chart Documentation.** The vendor shall submit to McDonnell for acceptance a flow chart showing the entire processing from incoming materials to final shipment. All processes and inspection points shall be identified by the applicable internal specification numbers to include revision and date. The disposition of this documentation shall also be indicated. Subsequent to McDonnell acceptance, changes must be reported to McDonnell before shipment of parts.
6. **NOTES.** Not applicable.

REVISED:	DRAWN	<i>JM</i>	APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS, DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			A			
	APPRD		APPRD			DRAWING NO.		SHEET	
						207-780003		12	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

↓

Lot Number _____	Specification _____
Part Number _____	P. O. Number _____
Manufacturer _____	Date Received _____
Lot Size _____	Sample Size _____
Quantity Accepted _____	Date Completed _____
Quantity Rejected _____	Lot Disposition _____
Date Code _____	Part Description _____
Lot S/N Range _____	Sample S/N Range _____

Tests Performed	No. Rejects Initial Meas.	Date	No. Rejects 2nd Meas.	Date	No. Rejects 3rd Meas.	Date	Insp. Stamp
1 Initial visual							
2							
3							
4							
5							
6							
7							
8							
9 Final Visual							

Serial Numbers of Rejected Parts								
Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9

Remarks: _____

Quality Assurance Manager

Figure 1. Sample Component Inspection Report Form

REVISED:	DRAWN	<i>[Signature]</i>	APPRD			GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD				DRAWING NO.		SHEET	
	APPRD		APPRD				207-780003		13	

MAC 1202A (REV 4 AUG 61) CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

TABLE I

Minimum Sample Size to be Tested to Assure an LTPD for Small Lot Quantities

Maximum LTPD	15	10	5	1
Acceptance Number	Minimum Sample Size			
0	17	22	45	231
1	28	38	77	390
2	38	52	105	533
3	49	65	132	668
4	58	78	159	798
5	68	91	184	927
6	77	104	210	1054
7	87	116	234	1178
8	95	128	258	1300
9	104	140	282	1421
10	113	152	307	1541

REVISED:	DRAWN	<i>[Signature]</i>	APPRD		GENERAL SPECIFICATION VOYAGER FLIGHT CAPSULE SEMICONDUCTORS, TRANSISTORS DIODES AND INTEGRATED CIRCUITS MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780003		14	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPROVED JUNE 1967 REVISED

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

APPLICATION		QTY/ ASSY	FIN. ART.	REVISIONS			
NEXT ASSY	USED ON			LTR	DESCRIPTION	DATE	APPROVED
DETAIL PART DRAWING							
CODE NO.	PART NO.	DRAWING OR SPECIFICATION	NOMENCLATURE OR DESCRIPTION	STOCK	MATL VENDOR NAME - ADDRESS		
PARTS LIST							
LIMITS UNLESS NOTED .x = $\pm .1$.xx = $\pm .03$.xxx = $\pm .010$		DRAWN <i>J.D. Montoya</i> ^{24 June 67}		MCDONNELL ST. LOUIS, MO.			
		CHECK					
		STRENGTH		INTEGRATED CIRCUIT FLIP FLOP, RST			
		GR ENGR					
APPD		PRO ENGR <i>[Signature]</i> ^{24 June 67}		SIZE A	CODE IDENT NO. 76301	207-780007	
FINISH SPEC		CUSTOMER		SCALE	SHEET 1 OF 15		
CONTRACT NO.							

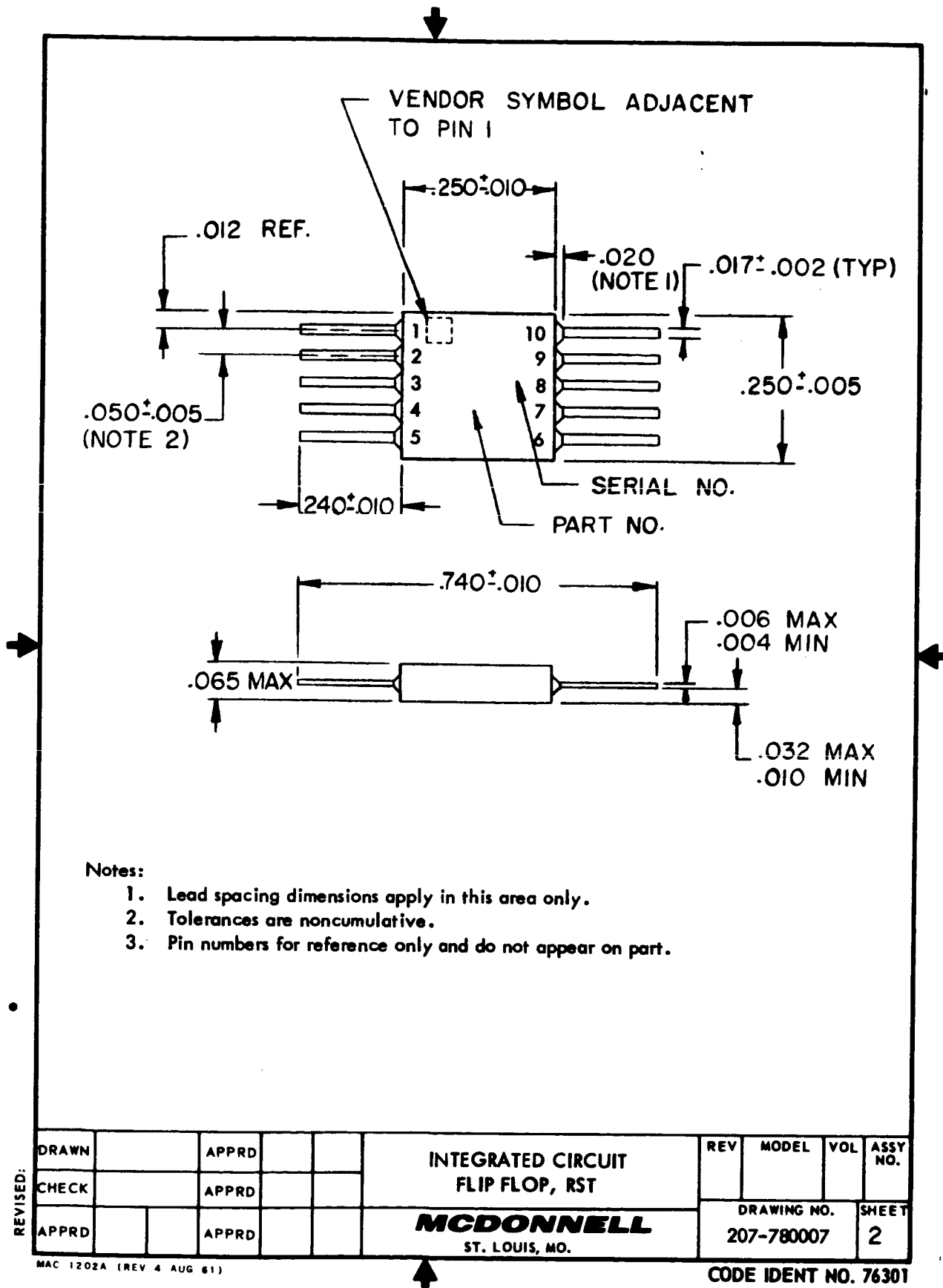
MAC 1187A (REV 24 NOV 65)

APPENDIX A

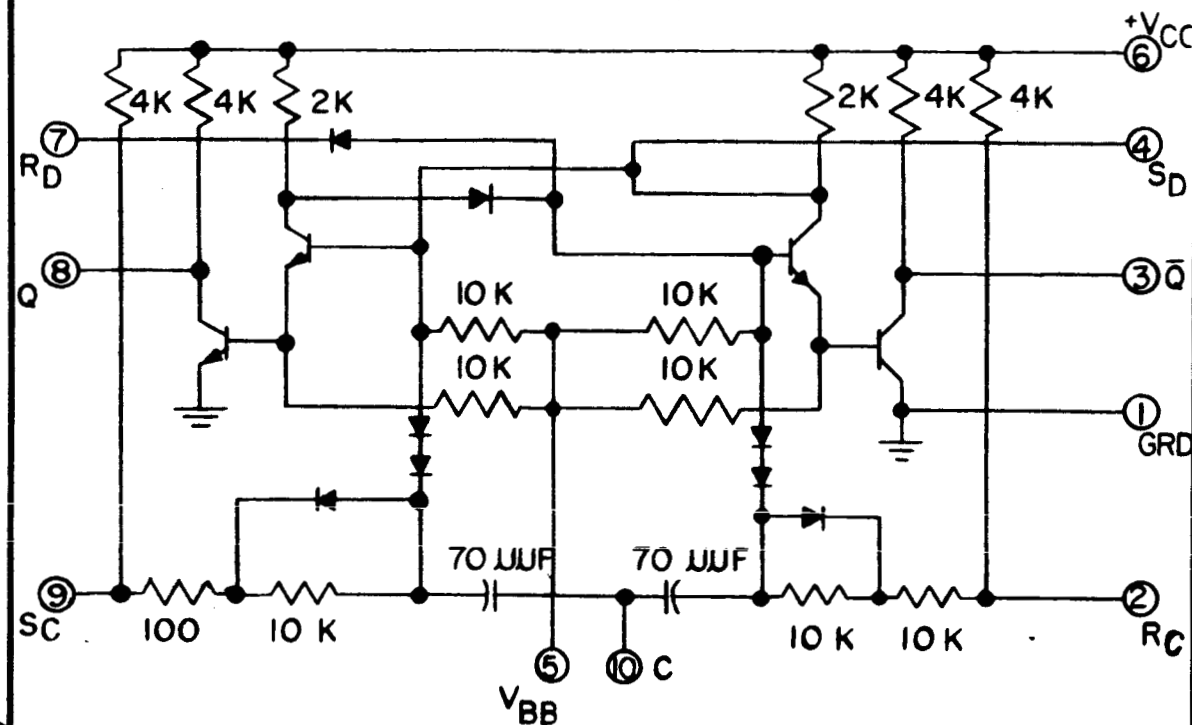
15

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS



APPENDIX A



SCHEMATIC DIAGRAM

REVISED:	DRAWN		APPRD		INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780007		3	

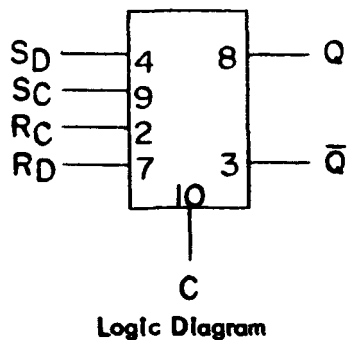
MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS



Clocked Set-Reset			Direct Set-Reset		
S_C	R_C	Q	S_D	R_D	Q
0	0	?	0	0	$\triangle 1$
0	1	1	0	1	1
1	0	0	1	0	0
1	1	No Change	1	1	No Change

Truth Table

Positive Logic Definitions: High Voltage = 1
Low Voltage = 0

$\triangle 1$ Both Q and \bar{Q} in 1 state until either S_D or R_D rises

Clocked set-reset Q is the logic state after the first negative going edge of the clock pulse at pin 10 with initial conditions before clock pulse at S_C and R_C as shown.

Table 1, Maximum Ratings (25°C)

Characteristic	Min.	Max.	Unit
Input Voltage (Pins 2, 3, 4, 7, 8, 9, 10)	0	+ 8	V
Output Voltage (Pins 3, 8)	0	+ 8	V
Vcc (Pin 6)	0	+8.2	V
Vbb (Pin 5)	0	- 8	V
Input Current (Pins 2, 3, 4, 7, 8, 9, 10)	- 30	+ 30	MA
Output Current (Pins 3, 8)	-100	+100	MA
Operating Temperature	- 55	+125	°C
Storage Temperature	- 65	+175	°C
Power Dissipation	—	150	MW

REVISED:	DRAWN		APPRD		INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780007		4	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

Notes:

1. General

- 1.1 These parts shall be specified, procured and used under the McDonnell approved part number 207-780007 (any vendor part number is for reference only).
- 1.2 These parts shall meet all requirements of McDonnell drawing 207-78003 except as noted herein.
- 1.3 All tests and measurements shall be performed at a temperature of $25 \pm 2^{\circ}\text{C}$ unless otherwise specified.
- 1.4 All symbols and abbreviations shall be as defined in MIL-S-19500.
- 1.5 All voltage and capacitance measurements are referenced to ground unless noted. Positive current flow is defined as into the pin referenced. Pins not specifically referenced are left open.

2. Requirements

2.1 Electrical

- 2.1.1 Performance characteristics shall be as specified in Table II (Group A) and Table IV (Group B) inspections.
- 2.1.2 The maximum electrical ratings shall be as specified in Table I when operated at an ambient temperature of 25°C .

2.2 Mechanical

- 2.2.1 Each device shall be of the design, construction and physical dimensions specified herein.
- 2.2.2 Leads shall be in accordance with MIL-STD-1276, Type K.
- 2.2.3 Devices shall be monolithic, planar passivated construction.

2.3 Environmental

- 2.3.1 Devices shall meet the end point test limits of Group B, Subgroup 2 before and after the sterilization heat test (6 cycles) per paragraph 3.7.1.1 of 207-780003.

REVISED:	DRAWN		APPRD			INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD				DRAWING NO.		SHEET	
	APPRD		APPRD				207-780007		5	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

2.3 Environmental (Continued)

2.3.2 Devices shall meet the end point test limits of Group B, Subgroup 2 before and after the ethylene oxide decontamination test (6 cycles) per paragraph 3.7.1.2 of 207-780003.

2.4 Failure Rate

2.4.1 The qualification approval devices shall demonstrate a maximum failure rate of 1.0 percent per 1,000 hours at 90 percent confidence level. Failures are defined as devices which do not meet the Table III (Group A) inspection requirements. During the life test, the devices shall be operated at $T_A = 125 \pm 2^\circ\text{C}$, dynamic operation at 100KHz in the circuit described in test circuit Figure 3.

2.5 Marking

2.5.1 Each device shall be permanently and legibly marked per McDonnell specification 207-780003, paragraph 3.10 with the following:

- Manufacturer's name or symbol
- Serial number in accordance with McDonnell specification 207-780003, paragraph 3.11
- McDonnell part number.

2.6 Quality Assurance

2.6.1 Qualification inspection shall consist of the examinations and tests specified in Tables II, III and IV in addition to the failure rate inspection of paragraph 2.4.

2.6.2 Acceptance inspection shall consist of the examinations and tests of Table II 100 percent process preconditioning and screening and Table III (Group A) inspections.

REVISED:	DRAWN		APPRD			INTEGRATED CIRCUIT FLIP FLOP, RST	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD							
	APPRD			APPRD			DRAWING NO. 207-780007		SHEET 6	
						MCDONNELL ST. LOUIS, MO.				

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

2.6 Quality Assurance (Continued)

2.6.3 Each device shall be photographed at 100X magnification, in color, just prior to final seal. Photographs shall be identified with device part number and serial number and delivered with the devices. Photographs shall have sufficient resolution to show scratches in conductor path, particle inclusions, etc.

2.7 Preparation for Delivery

2.7.1 Devices shall be prepared for delivery in accordance with McDonnell specification 207-780003, paragraph 5.

REVISED:	DRAWN		APPRD			INTEGRATED CIRCUIT FLIP FLOP, RST	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD							
	APPRD			APPRD			DRAWING NO. 207-780007		SHEET 7	
						MCDONNELL ST. LOUIS, MO.				

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

REVISED:

Table II 100% Process-Preconditioning and Screening									
Examination or Test		MIL-STD-750		Limits		Units			
		Method	Conditions						
Subgroup 1 Photograph High Temperature Storage Temperature Cycling Constant Acceleration Seal Fine Leak Gross Leak		1031	Paragraph 2.6.3 $T_A = 200 \pm 10^\circ C$ Condition C 30,000 g, Y_1 Axis	5×10^{-8}		cc/sec.			
		1051							
		2006							
			MIL-STD-202, Method 112C Condition C, Procedure IIIa MIL-STD-202, Method 112C Condition A, Ethylene Glycol						
Subgroup 2 Power Burn In End Points "1" Output Voltage (V3, V8) "0" Input Voltage (V4, V7, V10) "0" Output Voltage (V3, V8) "1" Input Current (I4, I7, I10)		1026	$T_A = 125 \pm 10^\circ C$ $t = 168$ Hours Dynamic Operation at 100Khz (Fig. 3) Per Group A, Subgroup 3	PDA-10			$\pm 20\%$ of Initial Value $\pm 20\%$ of Initial Value $\pm 0.1V$ 10 Times Initial Value		

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

DRAWN		APPRD			INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
CHECK		APPRD							
APPRD		APPRD				DRAWING NO. 207-780007		SHEET 7a	

APPENDIX A

REVISED:

Table III Group A Tests				Test Conditions (V6 = 4.0V, V5 = -2.0V, V1 = Ground unless otherwise noted)		Measurement Terminal	LTPD	Limits		Units
Examination or Test								Min.	Max.	
Subgroup 1 Visual and Mechanical Examination				MIL-STD-750 Method 2071 T _A = 25 ± 2° C						
Subgroup 2 Input Voltage (Breakdown)							1			
BVS _D				I _A = 10mA		V 4		8.0	-	V
BVR _D				I _I = 10mA		V 7		8.0	-	V
BVC				I _{I0} = 10mA		V10		8.0	-	V
Power Consumption										
I _{cc}				Tie V9 to V8, Tie V2 to V3		V 6		-	6.00	mA
Output Voltage										
BVQ				V6 = 8.2V, V4 = 0V		V 8		8.0	-	V
BVQ̄				V6 = 8.2V, V7 = 0V		V 3		8.0	-	V
Subgroup 3 "1" Output Voltage										
VQ ₁				V4 = 0.6V		V 8		3.9	-	V
VQ ₁ ̄				V7 = 0.6V		V 3		3.9	-	V
"0" Output Voltage										
VQ ₀				V4 = 1.7V, V7 = 0, I _B = +16mA		V 8		-	0.40	V
VQ ₀ ̄				V4 = 0, V7 = 1.7V, I _B = +16mA		V 3		-	0.40	V
"0" Input Current										
IS _{D0}				V4 = 0, V7 = 0		I 4		- 0.5	- 1.40	mA
IR _{D0}				V4 = 0, V7 = 0		I 7		- 0.5	- 1.40	mA
IR _{C0}				V10 = 0, V2 = 0		I 2		- 0.5	- 1.40	mA
IS _{C0}				V10 = 0, V9 = 0		I 9		- 0.5	- 1.40	mA
"1" Input Current										
IS _{D1}				V4 = 5.0V		I 4		-	100.00	nA
IR _{D1}				V7 = 5.0V		I 7		-	100.00	nA
IC ₁				V10 = 5.0V, V9 = 0, V2 = 0		I10		-	100.00	nA

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

REVISED:

DRAWN		APPRD		INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
CHECK		APPRD			DRAWING NO.		SHEET	
APPRD		APPRD			207-780007		9	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

Table III Group A Tests (Continued)

Examination or Test	Test Conditions (V6 = 4.0V, V5 = -2.0V, V1 = Ground unless otherwise noted)	Measurement Terminal	LTPD	Limits		Units
				Min.	Max.	
Subgroup 4			1			
"1" Output Voltage						
VQ1	V4 = .60V	I 8		3.8	-	V
VQ1	V7 = .60V	I 3		3.8	-	V
"0" Output Voltage						
VQ0	V4 = 1.7V, V7 = 0V, I8 = 16mA	I 8		-	.45	V
VQ0	V4 = 0V, V7 = 1.7V, I3 = 16mA	I 3		-	.45	V
"1" Input Current						
ISD1	V4 = 5.0V	V 4		-	10.00	uA
IRD1	V7 = 5.0V	V 7		-	10.00	uA
IC1	V10 = 5.0V, V9 = 0V, V2 = 0		1	-	10.00	uA
Subgroup 5						
"1" Output Voltage	T _A = -55 to +100°C					
VQ1	V4 = 0.6V	V 8		3.9	-	V
VQ1	V7 = 0.6V	V 3		3.9	-	V
"0" Output Voltage						
VQ0	V4 = 1.7V, V7 = 0V, I8 = 16mA	V 8		-	0.40	V
VQ0	V4 = 0V, V7 = 1.7V, I3 = 16mA	V 3		-	0.40	V
Subgroup 6	T _A = +25 ±2°C		1			
Clocked mode switching level	Test Circuit Figure 1	-		-	1.00	V
Clocked mode holding level	Test Circuit Figure 1	-		3.4	-	V
Clocked mode turn on delay	Test Circuit Figure 2	-		15.0	40.00	ns
Clocked mode turn off delay	Test Circuit Figure 2	-		10.0	40.00	ns

• 100 percent inspection

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS

REVISED:

Table III Group B Tests (Continued)									
		MIL-STD-750							
		Examination or Test		Method		Conditions		Limits	
DRAWN		Subgroup 5		1031		Per Group A, Subgroup 3 Non Operation, 1000 Hours T Min. = 150°C		10 Times Initial Value ± 20% Initial Value ± 20% Initial Value ± 0.1V	
CHECK		D.C. Parameters High Temperature Life End Points "1" Input Current "1" Output Voltage "0" Input Current "0" Output Voltage							
APPRD		Subgroup 6		1026		Per Group A, Subgroup 3 1000 Hours, T Min. = +125°C Dynamic Operation at 100 KC Test Circuit 3		10 Times Initial Value ± 20% Initial Value ± 20% Initial Value ± 0.1V	
		D.C. Parameters Operating Life End Points "1" Input Current "1" Output Voltage "0" Input Current "0" Output Voltage							

APPRD		APPRD		APPRD		INTEGRATED CIRCUIT FLIP FLOP, RST		REV	MODEL	VOL	ASSY NO.
APPRD		APPRD		APPRD		MCDONNELL ST. LOUIS, MO.		DRAWING NO. 207-780007		SHEET 11	

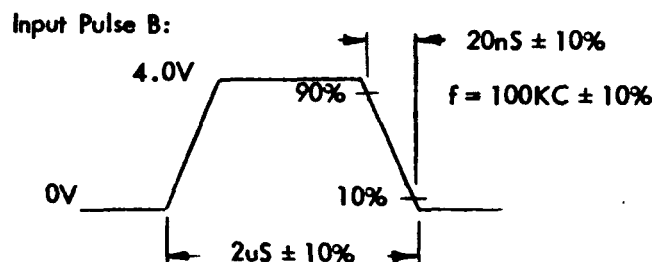
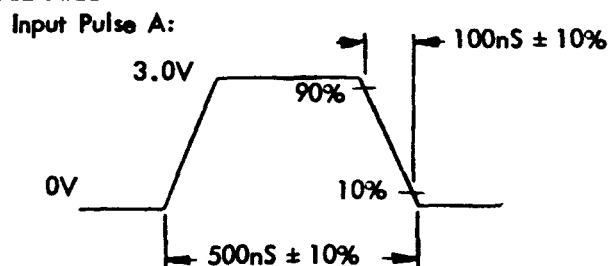
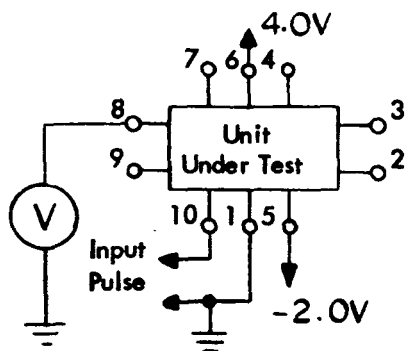
MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS



CLOCKED MODE SWITCHING LEVEL

Procedure:

- Set $V_G = 1.0$ Vdc; $V_2 = 4.0$ Vdc; momentary contact, V_7 to ground.
- Apply one input pulse to Pin 10.
- The device shall be rejected if it does not change state when the single input pulse is applied.
- Set $V_G = 4.0$ Vdc; $V_2 = 1.0$ Vdc; momentary contact, V_4 to ground.
- Apply one input pulse to Pin 10.
- The device shall be rejected if it does not change state when the single input pulse is applied.

CLOCKED MODE HOLDING LEVEL

- Apply input pulses.
- Set $V_2 = 3.4$ V, $V_G = 4.0$ V.
- Momentary contact, Pin 4 to Pin 1, V_G shall be high (> 3.5 V).
- The part shall be rejected if V_G does not remain high when Pin 4 is open.
- Set $V_2 = 4.0$ V, $V_G = 3.4$ V.
- Momentary contact, Pin 7 to Pin 1, V_G shall be low (< 0.5 V).
- The part shall be rejected if V_G does not remain low when Pin 7 is open.

FIGURE 1

REVISED:	DRAWN		APPRD		INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780007		12	

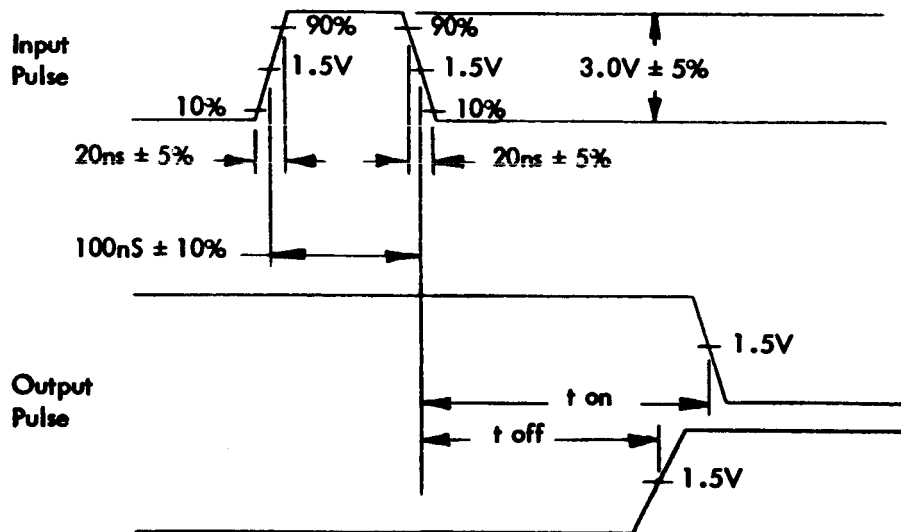
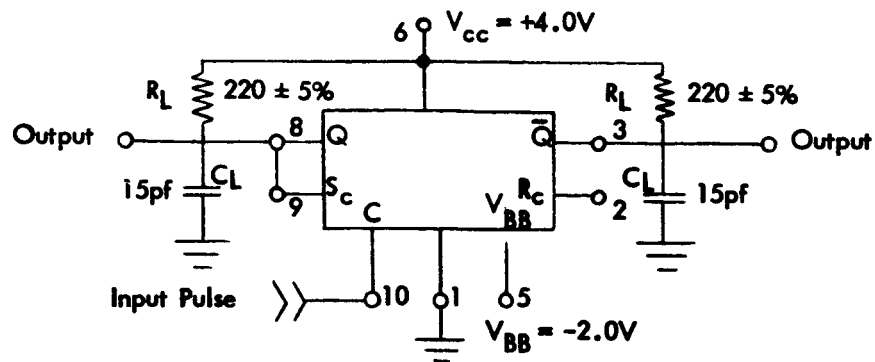
MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS



Note:
 C_L includes jig and probe capacitance

SWITCHING TIME TEST CIRCUIT
 FIGURE 2

REVISED:	DRAWN		APPRD		INTEGRATED CIRCUIT FLIP FLOP, RST MCDONNELL ST. LOUIS, MO.	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD			DRAWING NO.		SHEET	
	APPRD		APPRD			207-780007		13	

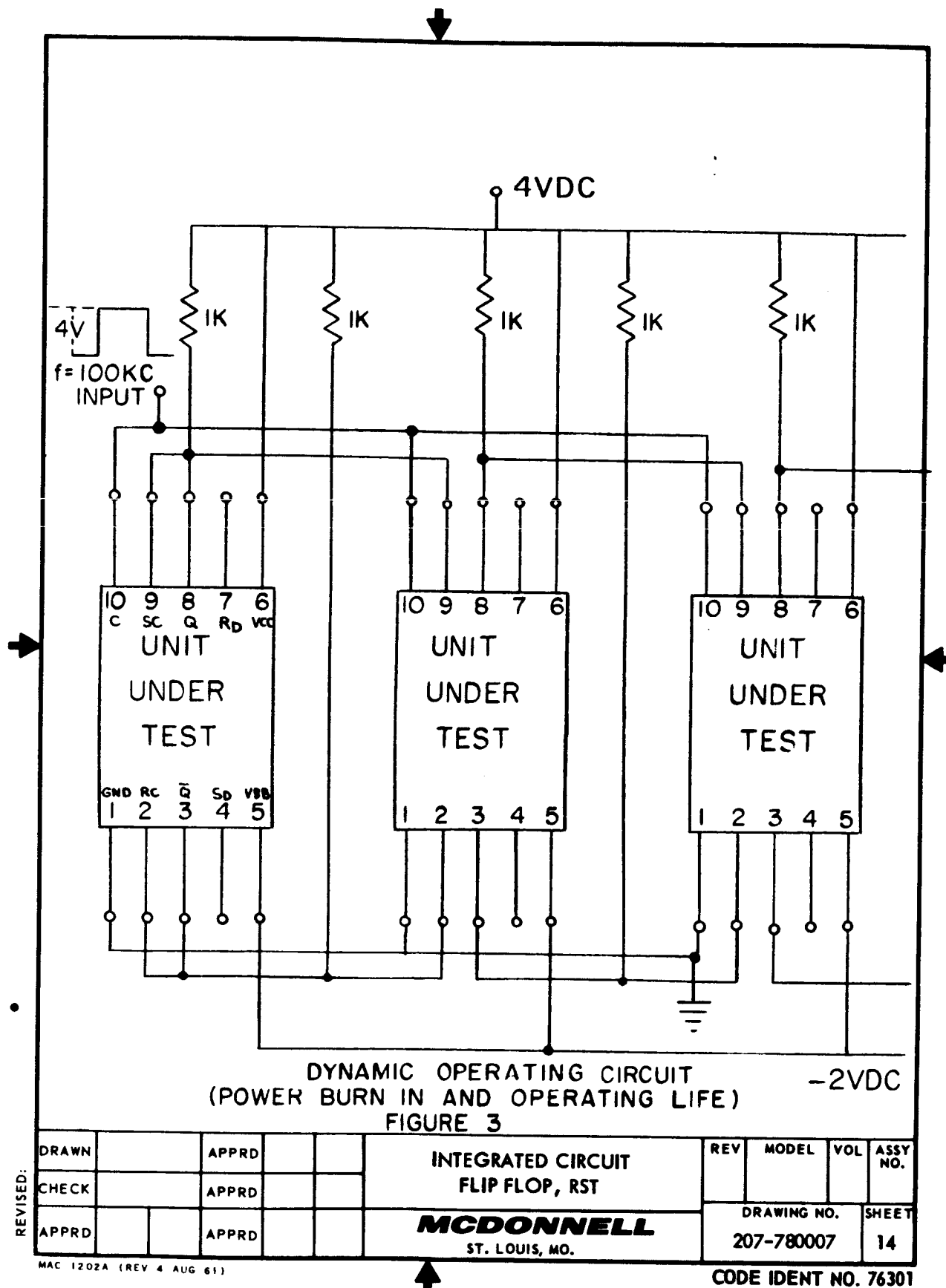
MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS



Parts shall be procured directly from the manufacturers listed under the following approved sources of supply:

Signetics Corporation (18324)
Sunnyvale, California

Part No. SE124G

The above listed vendors and designations are the only items and sources for parts specified herein approved for procurement and/or use on McDonnell products. Vendors of competitive articles may apply to the McDonnell Standards Engineering Department for approval as a source of supply.

REVISED:	DRAWN		APPRD			INTEGRATED CIRCUIT FLIP FLOP, RST	REV	MODEL	VOL	ASSY NO.
	CHECK		APPRD							
	APPRD			APPRD						
	MCDONNELL ST. LOUIS, MO.						DRAWING NO.		SHEET	
							207-780007		15	

MAC 1202A (REV 4 AUG 61)

CODE IDENT NO. 76301

APPENDIX A

REPORT F694 • VOLUME III • PART E • 31 AUGUST 1967

MCDONNELL ASTRONAUTICS